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Hazard Rating for Bark Beetle Susceptibility Using the Northern Region Vegetation Map (R1 VMap)

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EXECUTIVE SUMMARY

- Landscape level assessment of bark beetle hazard requires both a consistent, landscape level vegetation layer, as well as a methodology for rating that vegetation. The following describes how hazard ratings for numerous beetle-host combinations were attributed to the Northern Region's vegetation map (R1 VMap) so that landscape assessments can be conducted.
- The hazard criteria for the following bark beetle-host combinations are described in Randall and others (2019) and cover the following agents:
 - spruce beetle in Engelmann spruce
 - Douglas-fir beetle in Douglas-fir (also described in Egan et al. 2018)
 - mountain pine beetle (MPB) in lodgepole pine
 - MPB in whitebark pine / limber pine
 - MPB, western pine beetle, and aggressive *Ips* species (pine bark beetles) in ponderosa pine
 - pine bark beetles in ponderosa pine hosts based on SDI (as found in Egan et al. in press) assuming a severe outbreak (or drought)
 - pine bark beetles in ponderosa pine hosts based on SDI (as found in Egan et al. in press) assuming a low to moderate outbreak (or drought)
 - MPB, western pine beetle, and aggressive *Ips* in "combined" or all-pine hosts
 - Note that MPB in western white pine is not calculated for R1 VMap, and that ratings for MPB in whitebark/limber and for MPB, western and *Ips* in ponderosa pine are only partially calculated for the pre-2016 VMap products.
- The process of hazard rating R1 VMap for susceptibility to bark beetle activity required two different rating methods for VMap products pre-2016 and post-2016, and two rating categories,

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Conservative & Limited or Liberal & Complete, based on host dominance. The resulting ratings are provided in the traditional High, Moderate, Low, Very Low, as well as a hazard “code” that indicates the metadata on specific rating protocols for the VMap product and the host dominance. Use of this code allows for some flexibility in how the hazard ratings are used for particular objectives.

- These hazard ratings are the best and most appropriate ratings currently available for use across the Northern Region. However, as additional resources and data become available, we expect to continue updating and improving these tools.

BACKGROUND

Past efforts to apply hazard ratings to the Northern Region Existing Vegetation Mapping Program spatial database and map products (R1 VMap) used a statistical evaluation of the Northern Region FIA Summary Database (R1 Summary Database) (Bush 2014) to assign hazard ratings to the tree dominance 60% plurality types, canopy cover classes, and size classes (Steed et al. 2016). Until 2016, R1 VMap data was categorical (pre-2016 VMap) for all Forests, and the model chosen for defining a hazard was simple enough that the Summary Database had sufficient plots to complete the statistical evaluation across the Northern Region. Starting in 2016, R1 VMap products were released containing continuous data in ancillary tables. In addition to the added and more refined attributes available in more contemporary VMap products, the effects of beetle activity over the past 15-years have made our previous model less appropriate for current conditions. Thus, our updated hazard rating efforts evaluate Forests with pre- and post-2015 VMap attributes separately, and by necessity, rely more on professional assessment than in depth statistical analyses.

Although FHP no longer supports the previous R1 VMap hazard rating effort (Steed et al. 2016), descriptions of the R1 Summary Database (Bush 2014), the Existing Vegetation Mapping Program (Nelson et al. 2015, Berglund et al. 2009) and the Northern Region Existing Vegetation Classification System (Barber et al. 2009) still apply to understanding the updated hazard rating product.

METHODS

Bark Beetle Hazard Models

Most bark beetle hazard ratings described by Randall and others (2019) are included in the updated hazard ratings of current R1 VMap products. This current rating of VMap covers more beetle species and covers more stand types than previous efforts: Steed and others (2016) rated only bark beetles in pine species, and Egan and others (2018) rated only Douglas-fir beetle in stands dominated by Douglas-fir. We have also added a rating system for ponderosa pine based on a West-wide model for all yellow pines (Egan et al. in press).

The hazard criteria for the following insect (**acronym**) and host combinations are in this document. The hazard model acronym (**_HAZ**) reflects the Northern Region terminology used when referencing these hazard ratings in any Regional product (e.g. USDA Forest Service 2018). All hazard ratings are defined in Randall and others (2019):

- spruce beetle (**SB**) (*Dendroctonus rufipennis*) in Engelmann spruce (**SB_HAZ**)
- Douglas fir beetle (**DFB**) (*Dendroctonus pseudotsugae*) in Douglas-fir (**DFB_HAZ**) (see also Egan et al. 2018)
- mountain pine beetle (**MBP**) (*Dendroctonus ponderosae*) in lodgepole pine (**MPB_LP_HAZ**)

- mountain pine beetle (**MPB**) in whitebark pine / limber pine (**MPB_WBP_HAZ**)
- mountain pine beetle (**MPB**), western pine beetle (**WPB**) (*Dendroctonus brevicomis*) west of the Continental Divide, and more aggressive *Ips* species (**Ips**) in ponderosa pine (**MPB_WPB_PP_HAZ**)
- pine bark beetle (**MPB, WPB and Ips**) (*Dendroctonus* and *Ips* species) in “combined” or all pine hosts (**COMBO_MPB_HAZ**)
- pine bark beetles (*Dendroctonus* and *Ips* species) in ponderosa pine hosts assuming a severe outbreak (or drought) (**BB_PP_SDI_HAZ_S_PRES**) based on SDI (see also Egan and et al. in press)
- pine bark beetles (*Dendroctonus* and *Ips* species) in ponderosa pine hosts assuming a low to moderate outbreak (or drought) (**BB_PP_SDI_HAZ_LM_PRES**) based on SDI (see also Egan and et al. in press)

Note that mountain pine beetle (**MBP**) in western white pine (**MPB_WP_HAZ**) is not calculated for R1 VMap, and that MPB_WBP_HAZ and MPB_WPB_PP_HAZ are only partially calculated for pre-2016 VMap products.

The choice of model depends on host/beetle of concern. For the MPB-pines models, stands comprised of one pine host type - lodgepole, ponderosa, or high elevation 5-needle pines (whitebark-limber) - may be rated using the individual host model. If ponderosa pine is the only host of concern, we recommend the SDI-based hazard rating (**BB_PP_SDI_HAZ_S_PRES**). If multiple pine species are present, the combined pine host model (**COMBO_MPB_HAZ**) is the sole option. For any Region-wide applications **SB_HAZ**, **DFB_HAZ**, and **COMBO_MPB_HAZ** are the most appropriate models to assess **SB**, **DFB**, and **MBP** hazards.

The Northern Region insect hazard ratings provided in Randall and others (2019) are simplified and standardized. Most use the measurements of total stand basal area (**TBA**) (all species, all sizes), percent of basal area in host type (**%hostBA**) (%BA in host species and size classes divided by TBA), and quadratic mean diameter (**QMD**) of host trees (of host species and size classes) in all rating models. Thresholds of density, host dominance, and tree size determine the values used in the multiplicative index that estimates stand susceptibility. The example for spruce beetle is provided below (Table 1). In the spruce beetle model, QMD is determined from Engelmann spruce $\geq 10''$ in diameter at breast height (**DBH**) (at 4.5 feet from ground level). If a stand has a QMD of 11" DBH for all spruce $\geq 10''$, a TBA of 180 ft²/acre, of which 55% was spruce $\geq 10''$ DBH, the factors of 0.5, 3, and 2 would be multiplied ($=3$) to calculate a moderate (M) hazard rating for the stand. These model criteria and thresholds are carried through in our ratings of R1 VMap with some important caveats based on the fact that remote sensed data and ground-based inventory data do not contain the same information.

The Northern Region insect hazard ratings based on stand density index (**SDI**) based on Egan and others (in press) are based on assessment of yellow pine species across the western U.S. They don't use the multiplicative index described above but, rather, used conditional statements to parse out hazard/risk (Appendix F).

Table 1 Hazard Criteria for Spruce Beetle¹

Criteria	Attribute	Low (.5)	Moderate (2)	High(3)
A	QMD of Engelmann spruce $\geq 10''$ DBH	$<12''$	$12'' \leq \text{QMD} < 16''$	$\geq 16''$
B	BA for all species, all sizes (TBA)	$<100 \text{ ft}^2/\text{ac}$	$100 \leq \text{BA} < 150 \text{ ft}^2/\text{ac}$	$\geq 150 \text{ ft}^2/\text{ac}$
C	% of total BA (TBA) that is Engelmann spruce $\geq 10''$ DBH (%host)	$<50\%$	$50\% \leq \% \text{BA} < 65\%$	$\geq 65\%$

Directly Calculated Hazard Values and Hazard Rating Multiplicative Index

Hazard	Calculated Values	Hazard Rating
Very Low	0	0, VL
Low	<2	1, L
Moderate ¹	2-17	2, M
High ¹	≥ 18	3, H

¹For stands/plots with $< 40 \text{ ft}^2$ BA, hazard is rated as 'Low' due to reduced bark beetle habitat suitability at low stand densities (Randall et al. 2019)

These hazard ratings from Randall and others (2019) are used in numerous applications including 1) inventory data for Region 1 residing in NRM FSveg database, 2) common stand exam (CSE) data (USDA FS 2019) processed through the R1 Stand Exam Summary Database and loaded into FSveg Spatial (Bush et al. 2017) and 3) the FHP tool FINDIT (McMahan et al. 2019). In general, the basic hazard levels are as described in Table 2.

Table 2. Description of Hazard Rating Classes (_HAZ)

HAZARD	DESCRIPTION
VL	VERY LOW HAZARD: host trees are not present in plot data but plot is "forested" (some very low level of host could be present in stand); bark beetle impact is expected to be extremely low to non-existent
L	LOW HAZARD: host trees are either not abundant and/ or of sufficient size to be susceptible to pine bark beetle attack resulting in pine mortality but stand may have potential to grow into MODERATE or HIGH in the future.
M	MODERATE HAZARD: plot data indicates that there are enough host trees of appropriate size to be susceptible to pine bark beetle attack and subsequent pine mortality; some stands may have grown into HIGH hazard since VMAP layer was created
H	HIGH HAZARD: plot data indicates there are enough host trees of the appropriate size to be susceptible to pine bark beetle attack and significant subsequent pine mortality; this rating is conservative
Non-Forest	NO HAZARD: non-forested lands

R1 VMap hazard ratings, although modeled after Randall and others (2019), are unique and have been altered to fit the realities of R1 VMap data in several ways:

- The recent update to Randall and others (2019) requires a minimum TBA threshold of 40 ft^2/acre . If this threshold isn't met then hazard is dropped to Low. Although the canopy cover equivalent for 40 BA is likely higher than 10% (17% to 23% in ponderosa and lodgepole pines, respectively; Appendix C) we are using the R1 VMAP threshold of 10% canopy cover (required to be "forested") as the surrogate limit.
- Assumptions have been made to cross-walk stand characteristics used in Randall and others (2019) to R1 VMap. We assumed size class can be used for QMD and canopy cover can be used for BA and SDI. These stand characteristics differ by R1 VMap product (pre- and post-2016) and

are discussed under subsequent sections specific to the assessment of each R1-VMaP product type.

- We assumed that when host species dominance (%hostBA) drops below 40-50%, confidence in our cross-walk assumptions also drops. For this reason, and the likelihood that bark beetle-driven management decisions are not likely to occur in stands that are not predominantly host type, we created two “levels” of hazard ratings: one for stands that are predominantly host type (**Conservative & Limited**) and another for all remaining stands that are not predominantly host (**Liberal & Complete**). This means VMap hazard rating codes indicate hazard as well as host dominance.
- In Randall and others (2019) a rating of Very Low is for stands with trees but with no host species. In our rating of R1 VMap the amount of host type in this rating could range from 0% up to 10% of TBA.
- Note: for most purposes Low, and Very Low hazard ratings in R1 VMap should be combined.

Assessing VMap From 2016 or Later (“post-2016” or “new”)

Over time the data quality for R1 VMap has greatly increased in accuracy and detail, with additional hazard modeling opportunities provided by the new product’s ancillary tables. Specifically, these new ancillary tables contain continuous variables that allow for queries that better fit biological thresholds of the pest agents described in Randall and others (2019) than the categorical data divisions of the older VMAP.

Forests with post-2016 VMap (Table 3) were rated using criteria described in Randall and others (2019) (process described in Appendix B). However, we had to make some assumptions about equivalencies between these hazard criteria and data available in the remote sensed R1 VMap products. It is important to understand some of the assumptions made that allowed us to cross walk between hazard criteria in Randall and others (2019) and data available in the new R1 VMap ancillary tables:

- Assumed canopy cover of the stand (**CC**) in R1 VMap and total stand BA (TBA) in Randall and others (2019) have a direct relationship. Based on data for lodgepole and ponderosa pine stands from several locations in Montana (Appendix C) we calculated the relationship between CC and TBA for lodgepole and ponderosa pine-dominated stands, and applied it to other pine-host models, as well as the SB model. For Douglas-fir host, CC was dropped from hazard models completely (see Egan et al. 2018).
- Assumed that basal area weighted average diameter (**BAwtDBH**) (Barber et al 2011) of all trees in a stand (as found in R1 VMap ancillary tables) and QMD of host (for trees $\geq 5''$, $\geq 9''$ or $\geq 10''$ DBH depending on model) in Randall and others (2019) are roughly equivalent if the host is the predominant species in the stand (i.e. the BAwtDBH of the stand given in the ancillary tables will reasonably reflect QMD of the host species if host dominates the BA of the stand).
- Percent of TBA which is host (%hostBA) from Randall and others (2019) is considered roughly equivalent to the percentages of host species provided in the ancillary tables.

Table 3. National Forests (and Administrative Forest Number) in the Northern Region with “new” (2016 and newer) VMap data or limited to the older, categorical VMap data (pre-2016). Estimated years of the VMap update for the Forests with only older data is given.

OLD VMAP	Current (Planned Update)	NEW VMAP	Updated
Nez Perce (17) / Clearwater (5)	2014 (2020/2021)	Beaverhead / Deerlodge (2)*	2018
Custer (8) / Gallatin (11)	2015	Bitterroot (3) / Lolo (16)*	2016
Flathead (10)	2012 (2019/2020)	ID Panhandle (4)	2017
Helena (12) / Lewis & Clark (15)	2014	Kootenai (14)	2017

*The Deerlodge and Lolo National Forest areas are covered principally by the “new” VMap product, with small areas lacking the new VMap data (administered lands under other National Forest boundaries) that have only the older VMap. The R1 rating tools apply the ratings first to the “new” VMap portion, and then fill in the missing ratings in the “old” portion.

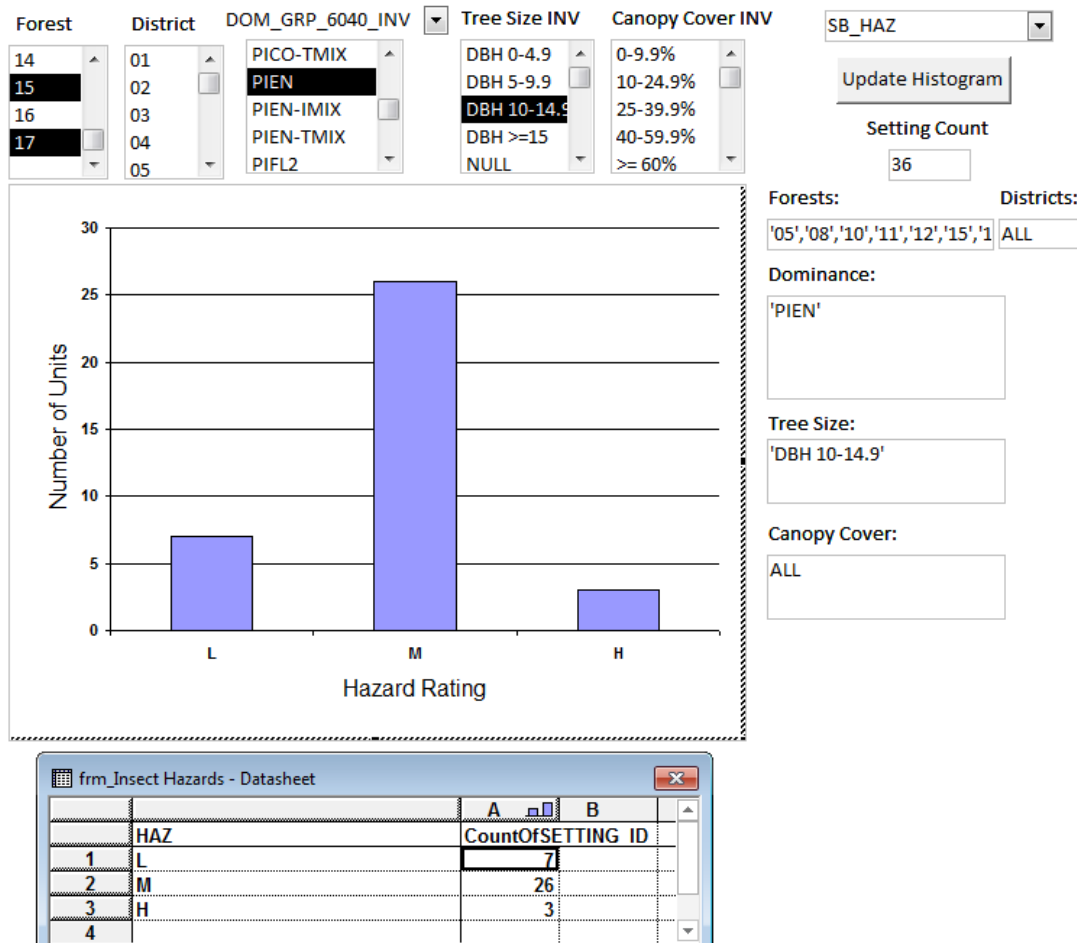
Assessing Pre-2016 VMap (or “old”)

Hazard rating of the “old” VMap product was completed on Forests that do not have the more contemporary ancillary tables (Table 3). The older VMap product is more difficult to rate because breaks used to delineate the categorical division do not match the thresholds in the bark beetle hazard ratings. For example, the MPB_LPP_HAZ model uses the thresholds of 7”DBH and 8” DBH (Randall et al 2019) but the R1 VMap tree size category of 5-10” DBH encompasses both size criteria thresholds. Thus, there is no straight forward way to cross walk the old R1 VMap categories to the bark beetle hazard ratings. Instead, we used the R1 FIA Summary Database (Bush 2014; Barber et al 2011) to determine appropriate hazard ratings for different host, size class, and canopy cover combinations.

The R1 FIA Summary Database is derived from USDA Forest Service Forest Inventory and Analysis (FIA) plots (Bush and Reyes 2016) and is attributed with general stand descriptions, bark beetle hazard ratings (Randall et al. 2019), and the Northern Region Existing Vegetation (R1 ExVeg) classification system descriptors (Barber et al.2011) also used in classifying R1 VMap polygons. With this dataset we can assess the number of High, Moderate, Low, and Very Low hazard plots that are binned into any given Forest/District, forest type (Dom_Grp_6040), tree size class, or canopy cover class using a form within the R1 FIA Summary Database that displays the ranges of a specified insect hazard based on selected dominance types, size classes, and canopy cover classes “frm_Insect Hazards” (Fig. 1) (Bush 2014).

Assumptions about equivalencies between hazard rating criterial and data available in the remote sensed R1 VMap products are similar to those of the “new” VMap, but are less critical because assignment of hazard is based on the “populations” of plot hazards in the categorical vegetation bins and not biological thresholds indicated in the hazard ratings. However, hazard assignment is also more subjective in that binning decisions attempt to increase capture of High and Moderate hazards without greatly increasing the population of Low and Very Low hazard. Also, host dominance is based on $\geq 40\%$ as dictated by the dominance classes (e.g. Dom40) rather than $\geq 50\%$ as used in the post-2016 VMap ratings.

Figure 1. Example of the R1 Summary Database form used to assess hazard of defined R1 ExVeg groups



RESULTS and PRODUCTS

The Hazard Ratings

The process of hazard rating R1 VMap for susceptibility to bark beetle activity is divided into ratings of the two VMap products (old and new), and into two rating categories (Conservative & Limited or “Cons-Lim” in queries; Liberal & Complete or “Lib-Comp” in queries) based on host dominance. The resulting hazard ratings are provided in the traditional High, Moderate, Low, Very Low (_HAZ) (Table 2), as well as a hazard code (_HAZ_CODE) that indicates hazard level, as well as host dominance and the rating protocols. These codes are defined in Appendix A.

Note that the Randall et al. (2019) model for ponderosa pine (MPB_WPB_PP) is limited to the Conservative & Limited query only. For this reason, as well as our confidence in the model, we recommend using the SDI based hazard rating for western yellow pines to rate ponderosa pine in R1 (Appendix F; Egan et al. in press). These SDI-based ratings have their own unique hazard codes (Appendix A).

These hazard ratings are the best and most appropriate ratings currently available for use across the Northern Region. However, as additional resources and data become available, we expect to continue updating and improving these tools.

Arc MAP Tool for rating R1 VMap directly

Because some Forests are updating VMap polygon attributes, esp. for older VMap products, and to facilitate processing speed, the queries described in Appendices D and E have been developed into a GIS tool (VMap_InsectHaz.tbx). This tool is described in Appendix I and T:\FS\Reference\GeoTool\r01\Toolbox\NRGG-UG_R1_Insect_Hazard_Toolbox.pdf. The python script for all ratings together is provided as Appendix G for the new VMap products and Appendix H for the old VMap products.

Tool incorporated into FS Veg Spatial

Stand exam data, residing in FSveg (Bush and Fikstad 2018), can be summarized to create a Stand Exam Summary Database, which contains all FHP hazard ratings. This data can be loaded into FSveg Spatial (Bush et al. 2017).

Data collected using the R1 FSveg Spatial Walk-through protocols is summarized to create a Walk-through Summary Database that can also be loaded into FSveg Spatial. In the future, this Walk-through SDB will also contain the regional hazard ratings assigned, based on the walk-through data.

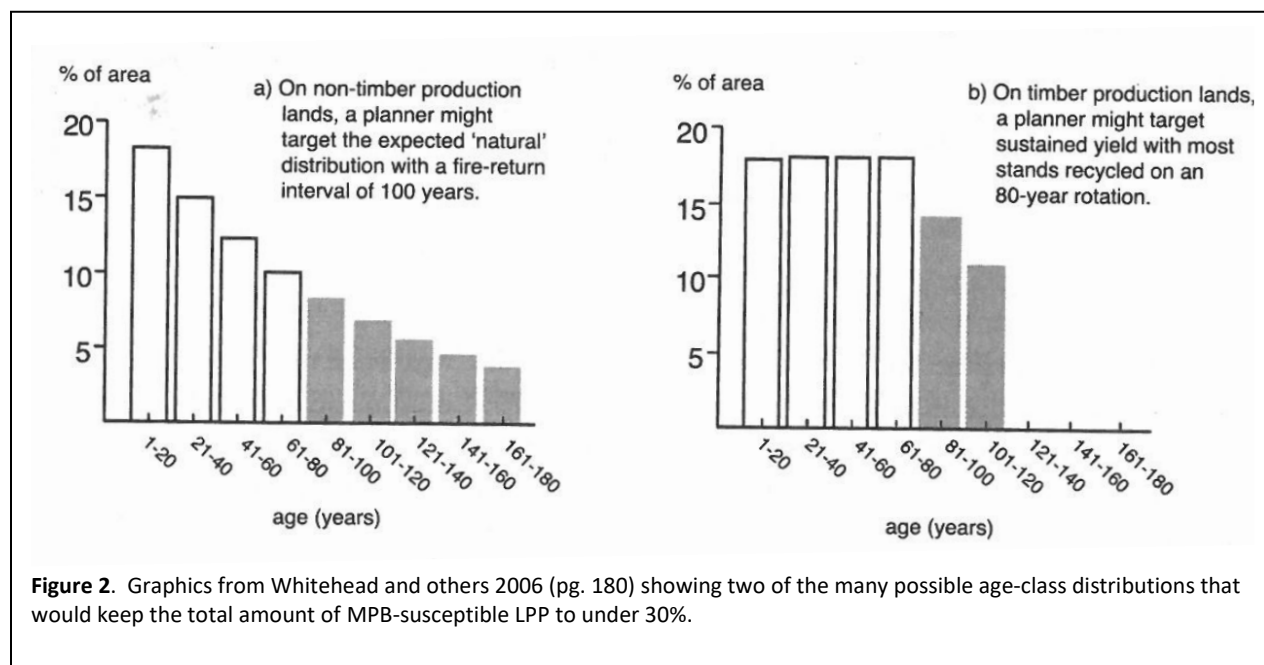
The FSveg Spatial /R1-VMerge Tool allows the user to create a hybrid existing vegetation layer that give precedence to FSveg Spatial polygons from Stand Exams (or Walk-throughs?) and tabular attributes when they are populated. This allow a continuous existing vegetation layer for dominance type, size class, canopy cover class and the hazard ratings, using the more robust information attributed from stand exams and walk-throughs, where they are available. The Merge Tool itself uses the same or similar python code described in the Appendices G and H to attribute VMap polygons with the bark beetle hazard ratings described in this report

DISCUSSION ON LANDSCAPE APPLICATION

Based on stand-level hazard ratings such as those found in Randall and others (2019) susceptibility to bark beetles (and defoliators) can be lowered by changing stand conditions to levels below the identified thresholds. However, for some forest types, stand-level treatments that lower stand density, host dominance, or host QMD are often not viable options. This is particularly true for lodgepole pine which is prone to windthrow when thinned. For management of lodgepole against MPB it may be more relevant to consider susceptibility and treatments at the landscape level. If thresholds for the number of acres or the pattern of susceptible stands can be identified, management could limit outbreak potential and mitigate landscape impacts (i.e. resistance and resilience). With R1-VMaP, a tool to look at landscape level hazard is now available.

Focusing solely on stand-level hazard does not consider the impact of surrounding vegetation susceptibility which can influence the probability of outbreak occurrence and the degree of bark beetle population pressure that may challenge a given stand. Landscape mosaics can be considered to both limit the total amount of susceptible host and reduce susceptible stand continuity to reduce migration corridors that allow MPB outbreaks to successfully progress through landscapes. This susceptible host continuity can be broken up through fire or silvicultural treatments that promote structural and compositional forest diversity and a “species-age mosaic” (Shore and Safranyik 2004).

Whitehead and others (2006, pg. 177) describe the MPB-lodgepole pine management concept well: “When planning preventive management, forested landscapes must be considered as a collection of stands where specific characteristics of individual stands and arrangement of stands relative to each other in space and time are both important in determining susceptibility.” In non-production landscapes, they suggest a planner could target and expect “natural” age distribution with a fire-return interval of 100 years (Fig. 2-left). Where management is for timber production, the planner might aim for harvest of susceptible stands which could allow for more regeneration (Fig. 2 -right). In both scenarios, under 30% of the lodgepole pine stands are highly susceptible (Whitehead et al. 2006; Whitehead et al. 2004. The amount of the analysis area composed of lodgepole pine forest was not discussed but they explain that their study areas are lodgepole pine-dominated landscapes.



Interestingly, a separate Canadian study looked at MPB-susceptibility across the landscape and found that in the absence of fire exclusion and other management influences (a more natural landscape condition) highly susceptible age classes ranged from 17-25% of the landscape (Taylor and Carroll 2004; Taylor et al. 2006). Similarly, our Northern Region data predicts that a severe MPB outbreak is **likely** during the next substantial drought period when 26-40% of the total subwatershed area is highly susceptible to MPB-attack and is **extremely likely** when that area exceeds 40%. (Egan et al.—unpublished).

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APPENDIX A: BARK BEETLE HAZARD RATING CODES APPLIED TO VMAP

(Directly with GIS tool [Appendix I] or through FSveg Spatial)

HAZARD RATING CODE	HAZ LEVEL	DATA SOURCE	HOST DOMINANCE	APPLIES TO:
0	VERY LOW	FSVeg Spatial ¹	(see model)	FVS applied ratings given to polygons in FSVeg Spatial
1	LOW	FSVeg Spatial	(see model)	FVS applied ratings given to polygons in FSVeg Spatial
2	MOD	FSVeg Spatial	(see model)	FVS applied ratings given to polygons in FSVeg Spatial
3	HIGH	FSVeg Spatial	(see model)	FVS applied ratings given to polygons in FSVeg Spatial
4	NOT FORESTED	FSVeg Spatial	--	FVS applied ratings given to polygons in FSVeg Spatial
101	LOW	Old VMap	>=40%	"Conservative & Limited" ² for Old VMap categorical data
102	MOD	Old VMap	>=40%	"Conservative & Limited" for Old VMap categorical data
103	HIGH	Old VMap	>=40%	"Conservative & Limited" for Old VMap categorical data
104	NOT FORESTED	Old VMap	--	"Conservative & Limited" for Old VMap categorical data
200	VERY LOW	Old VMap	<40%	"Liberal & Complete" ³ for Old VMap categorical data
201	LOW	Old VMap	<40%	"Liberal & Complete" for Old VMap categorical data
202	MOD	Old VMap	<40%	"Liberal & Complete" for Old VMap categorical data
301	LOW	New VMap	>=50% 40% for PP	"Conservative & Limited" for New VMap using ancillary tables
302	MOD	New VMap	>=50% 40% for PP	"Conservative & Limited" for New VMap using ancillary tables
303	HIGH	New VMap	>=50% 40% for PP	"Conservative & Limited" for New VMap using ancillary tables
304	NOT FORESTED	New VMap	--	"Conservative & Limited" for New VMap using ancillary tables
400	VERY LOW	New VMap	<50% 40% for PP	"Liberal & Complete" for New VMap using ancillary tables
401	LOW	New VMap	<50% 40% for PP	"Liberal & Complete" for New VMap using ancillary tables
402	MOD	New VMap	<50% 40% for PP	"Liberal & Complete" for New VMap using ancillary tables
403 ⁴	HIGH	New VMap	<50% 40% for PP	"Liberal & Complete" for New VMap using ancillary tables
501	LOW	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP - Severe
502	MOD	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP - Severe
503	HIGH	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP - Severe
504	NOT FORESTED	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP - Severe
600	VERY LOW	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP - Severe
601	LOW	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP - Severe
602	MOD	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP - Severe
701	LOW	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP – Low/Mod
702	MOD	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP – Low/Mod
703	HIGH	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP – Low/Mod
704	NOT FORESTED	Old & New VMap	>=50%	"Conservative & Limited" for updated BB in PP – Low/Mod
800	VERY LOW	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP – Low/Mod
801	LOW	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP – Low/Mod
802	MOD	Old & New VMap	<50%	"Liberal & Complete" for updated BB in PP – Low/Mod
900	not assessed	Old & New VMap	<40% or <50%	"Conservative & Limited" for polygons with limited host not given an additional "Liberal & Complete" hazard rating

¹ %BA in Host: in Randall et al. 2019 this is usually for trees 5" in size (or some size limit). In VMAP this is total BA without a size limit, although because it's remote sensed data it may not capture understory BA

² Size: in Randall et al. 2019 this is usually QMD for host trees 5" or larger ($\geq 10"$ DBH for spruce beetle example). In VMAP this is calculated as BA weighted diameter of all species.

³ Density: in Randall et al. 2019 this is given as total BA (usually considered as being trees 5" or larger). In VMap there is not BA so Canopy Cover (CC) is the best surrogate. For the pines, we assign canopy cover levels based on data for either lodgepole or ponderosa pines (Appendix C)

⁴ Randall et al. (2019) has a 40% total stand BA threshold, below which stands are rated as 'Low' hazard. VMap protocols have 10% canopy cover requirement to be considered forested. Although the canopy cover equivalent for 40BA is likely higher than 10% (17% to 23% in ponderosa and lodgepole pines, respectively) we are using the 10% canopy cover threshold of VMAP as the surrogate.

APPENDIX B: CROSS WALK STEPS FOR R1 BARK BEETLE HAZARD RATINGS (Randall and others 2019) AND NEW VMAP PRODUCTS (post-2015)

Table B1. Calculation of spruce beetle hazard: The surrogate R1 VMap new ancillary table criteria (purple highlight) are used in the multiplicative index to determine the final hazard rating as defined in Randall and others 2019 protocols.

%TBA in HOST (of trees size X) ¹	QMD of host trees (size X) ²	Total BA of Stand ^{3, 4}	%HOST	SIZE	DENSITY	Index	HAZRate
%TBA in Host ¹	BAwtDBH ²	CC ^{3, 4}					
PIEN >=65%	BAwtDBH >=16"	CC >=45%	3	3	3	27	H
PIEN >=65%	BAwtDBH >=16"	CC 35-44.9%	3	3	2	18	H
PIEN >=65%	BAwtDBH >=16"	CC 10-35% ⁴	3	3	0.5	4.5	M
PIEN >=65%	BAwtDBH 12-15.9"	CC >=45%	3	2	3	18	H
PIEN >=65%	BAwtDBH 12-15.9"	CC 35-44.9%	3	2	2	12	M
PIEN >=65%	BAwtDBH 12-15.9"	CC 10-35%	3	2	0.5	3	M
PIEN >=65%	BAwtDBH <12"	CC >=45%	3	0.5	3	4.5	M
PIEN >=65%	BAwtDBH <12"	CC 35-44.9%	3	0.5	2	3	M
PIEN >=65%	BAwtDBH <12"	CC 10-35%	3	0.5	0.5	0.75	L
PIEN 50-64%	BAwtDBH >=16"	CC >=45%	2	3	3	18	H
PIEN 50-64%	BAwtDBH >=16"	CC 35-44.9%	2	3	2	12	M
PIEN 50-64%	BAwtDBH >=16"	CC 10-35%	2	3	0.5	3	M
PIEN 50-64%	BAwtDBH 12-15.9"	CC >=45%	2	2	3	12	M
PIEN 50-64%	BAwtDBH 12-15.9"	CC 35-44.9%	2	2	2	8	M
PIEN 50-64%	BAwtDBH 12-15.9"	CC 10-35%	2	2	0.5	2	M
PIEN 50-64%	BAwtDBH <12"	CC >=45%	2	0.5	3	3	M
PIEN 50-64%	BAwtDBH <12"	CC 35-44.9%	2	0.5	2	2	M
PIEN 50-64%	BAwtDBH <12"	CC 10-35%	2	0.5	0.5	0.5	L
PIEN <50%	BAwtDBH >=16"	CC >=45%	0.5	3	3	4.5	M
PIEN <50%	BAwtDBH >=16"	CC 35-44.9%	0.5	3	2	3	M
PIEN <50%	BAwtDBH >=16"	CC 10-35%	0.5	3	0.5	0.75	L
PIEN <50%	BAwtDBH 12-15.9"	CC >=45%	0.5	2	3	3	M
PIEN <50%	BAwtDBH 12-15.9"	CC 35-44.9%	0.5	2	2	2	M
PIEN <50%	BAwtDBH 12-15.9"	CC 10-35%	0.5	2	0.5	0.5	L
PIEN <50%	BAwtDBH <12"	CC >=45%	0.5	0.5	3	0.75	L
PIEN <50%	BAwtDBH <12"	CC 35-44.9%	0.5	0.5	2	0.5	L
PIEN <50%	BAwtDBH <12"	CC 10-35%	0.5	0.5	0.5	0.125	L
PIEN <10%	all	all					VL

¹ %BA in Host: in Randall et al. 2019 this is usually for trees 5" in size (or some size limit). In VMAP this is total BA without a size limit

² Size: in Randall et al. 2019 this is usually QMD for host trees 5" or larger (>=10" DBH for spruce beetle example). In VMAP this is calculated as BA weighted diameter of all species.

³ Density: in Randall et al. 2019 this is given as total BA (usually considered as being trees 5" or larger). In VMap there is not BA so Canopy Cover (CC) is the best surrogate. For the pines, we assign canopy cover levels based on data for either lodgepole or ponderosa pines (Appendix C)

⁴ Randall et al. (2019) has a 40 sqft total stand BA threshold, below which stands are rated as 'Low' hazard. VMap protocols have 10% canopy cover requirement to be considered forested. Although the canopy cover equivalent for 40 BA is likely higher than 10% (17% to 23% in ponderosa and lodgepole pines, respectively) we are using the 10% canopy cover threshold of VMAP as the surrogate.

Using all possible groupings of hazard rating criteria (e.g. Table 2) were grouped by Hazard Level, and collapsed to simplify queries. These queries were somewhat different depending on whether the lower threshold of %host was $\geq 40\%$ (DFB, SB, beetles in PP) or lower ($< 40\%$) (COMBO PINE, LPP).

Table B2. The matrix of all criteria levels and their Multiplicative Index values (and equivalent hazard rating). Within hazard level (High, Moderate, Low, Very Low) and host level ($\geq 50\%$ host or $< 50\%$ host by BA) each criteria "set" such as those in green highlight will be collapsed to simplify the final description in VMap.

%BA in HOST	%BA Threshold ¹	QMD of trees size X ²	Total BA	%BA HOST	QMD	Total BA	Index	HAZ Rate
HIGH HAZARD		$\geq 50\%$ host						
PIEN $\geq 65\%$		BAwtDBH $\geq 16"$	CC $\geq 45\%$	3	3	3	27	H
PIEN $\geq 65\%$		BAwtDBH $\geq 16"$	CC 35-44.9%	3	3	2	18	H
PIEN $\geq 65\%$		BAwtDBH 12-15.9"	CC $\geq 45\%$	3	2	3	18	H
PIEN 50-64%		BAwtDBH $\geq 16"$	CC $\geq 45\%$	2	3	3	18	H
MODERATE HAZARD		$\geq 50\%$ host						
PIEN $\geq 65\%$		BAwtDBH $\geq 16"$	CC 10-35%	3	3	0.5	4.5	M
PIEN $\geq 65\%$		BAwtDBH 12-15.9"	CC 35-44.9%	3	2	2	12	M
PIEN $\geq 65\%$		BAwtDBH 12-15.9"	CC 10-35%	3	2	0.5	3	M
PIEN $\geq 65\%$		BAwtDBH $< 12"$	CC $\geq 45\%$	3	0.5	3	4.5	M
PIEN $\geq 65\%$		BAwtDBH $< 12"$	CC 35-44.9%	3	0.5	2	3	M
PIEN 50-64%		BAwtDBH $\geq 16"$	CC 35-44.9%	2	3	2	12	M
PIEN 50-64%		BAwtDBH $\geq 16"$	CC 10-35%	2	3	0.5	3	M
PIEN 50-64%		BAwtDBH 12-15.9"	CC $\geq 45\%$	2	2	3	12	M
PIEN 50-64%		BAwtDBH 12-15.9"	CC 35-44.9%	2	2	2	8	M
PIEN 50-64%		BAwtDBH 12-15.9"	CC 10-35%	2	2	0.5	2	M
PIEN 50-64%		BAwtDBH $< 12"$	CC $\geq 45\%$	2	0.5	3	3	M
PIEN 50-64%		BAwtDBH $< 12"$	CC 35-44.9%	2	0.5	2	2	M
MODERATE HAZARD		$< 50\%$ host						
PIEN $< 50\%$		BAwtDBH $\geq 16"$	CC $\geq 45\%$	0.5	3	3	4.5	M
PIEN $< 50\%$		BAwtDBH $\geq 16"$	CC 35-44.9%	0.5	3	2	3	M
PIEN $< 50\%$		BAwtDBH 12-15.9"	CC $\geq 45\%$	0.5	2	3	3	M
PIEN $< 50\%$		BAwtDBH 12-15.9"	CC 35-44.9%	0.5	2	2	2	M
LOW HAZARD		$\geq 50\%$ host						
PIEN $\geq 65\%$		BAwtDBH $< 12"$	CC 10-35%	3	0.5	0.5	0.75	L
PIEN 50-64%		BAwtDBH $< 12"$	CC 10-35%	2	0.5	0.5	0.5	L
LOW HAZARD		$< 50\%$ host						
PIEN $< 50\%$		BAwtDBH $\geq 16"$	CC 10-35%	0.5	3	0.5	0.75	L
PIEN $< 50\%$		BAwtDBH 12-15.9"	CC 10-35%	0.5	2	0.5	0.5	L
PIEN $< 50\%$		BAwtDBH $< 12"$	CC $\geq 45\%$	0.5	0.5	3	0.75	L
PIEN $< 50\%$		BAwtDBH $< 12"$	CC 35-44.9%	0.5	0.5	2	0.5	L
PIEN $< 50\%$		BAwtDBH $< 12"$	CC 10-35%	0.5	0.5	0.5	0.125	L
VERY LOW HAZARD		$< 50\%$ host						
PIEN $< 10\%$				0.5				VL

¹Threshold levels of host vary somewhat by model with most models using the new VMap ancillary tables having a 50% host threshold. The Randall and others (2019) model for pine bark beetles in ponderosa pine has a 40% threshold.

²QMD in Randall and others (2019) is based on trees greater than a certain size. For most pine models this is a 5" DHB threshold. For spruce beetle it is $\geq 10"$ and for Douglas-fir beetle it is $\geq 9"$.

Table B3. The final hazard rating descriptions by host level, collapsed to include all criteria “sets” in the most simplified terms.

HAZARD (CODE)	%HOST	SIZE	CC
>=50% host			
High (303)	PIEN >=65%	BAwtDBH >=16" BAwtDBH 12-15.9"	>=35% >=45%
	PIEN 50-64%	BAwtDBH >=16"	>=45%
Moderate (302)	PIEN >=65%	BAwtDBH >=16" BAwtDBH 12-15.9"	<35% <45%
	PIEN 50-64%	BAwtDBH >=16" BAwtDBH 12-15.9"	<45 all CC >10%
	PIEN >=50%	BAwtDBH <12"	>=35%
	PIEN >=50%	BAwtDBH <12"	<35%
Low (301)	PIEN >=50%	BAwtDBH <12"	<35%
<50% host			
Moderate (402)	PIEN 10-50%	>=12"	>=35%
Low (401)	PIEN 10-50%	>=12"	<35%
		BAwtDBH <12"	all CC >10%
VeryLow (400)	PIEN <10%		

APPENDIX C: CANOPY COVER AND BASAL AREA RELATIONSHIPS IN PINE

The relationship between canopy cover (CC) and basal area (BA) was calculated for lodgepole pine and ponderosa pine from plots in eastern Montana (Egan and Hayes 2016). Only plots with $\geq 50\%$ host type (by basal area) were used. The models created are considered a reasonable approximation for the CC-BA crosswalks necessary to apply Randall and others (2019) hazard ratings to VMap data.

Lodgepole pine - BA to CC

Data for ponderosa pine (n=644) included plots where the QMD of stands ranged from 1" DBH to 13" DBH (predominantly 3" to 11" DBH) (Figure C1), basal areas ranged to over 300 square feet per acre, and had 50% host type or greater. The plot of all points is shown in Figure C2 predictive relationship is described by the equation:

Canopy Cover of LPP = $11.048947 + (0.322446 \cdot BA) + (-0.0004300 \cdot BA^2)$ ($R^2=71\%$; $p<0.001$) (Table C1)

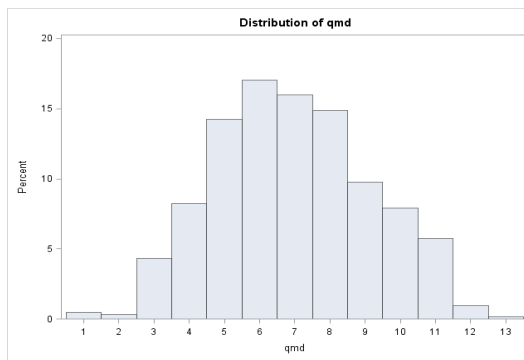


Figure C1. Distribution of quadratic mean diameters of lodgepole pine dominated plots.

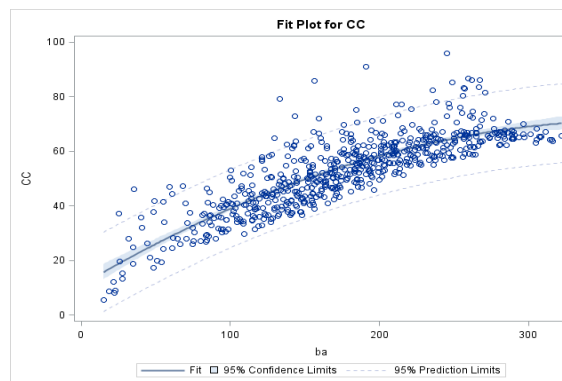
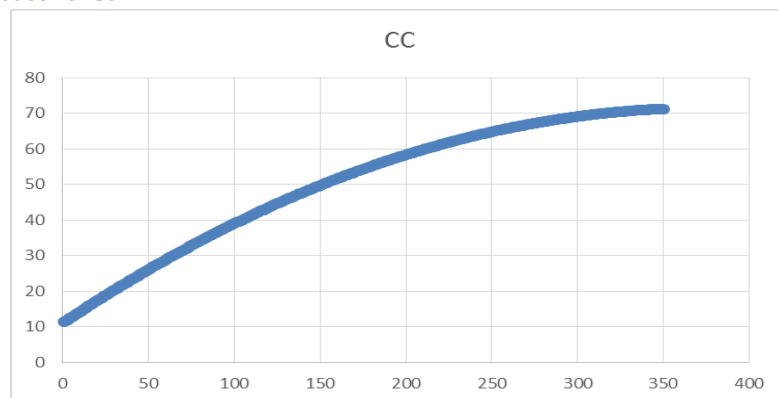


Figure C2 Distribution of data points, best fit curve, and 95% prediction limits for data on lodgepole pine.

Table C1 Plot and parameters for equations describing the relationship between canopy cover and basal area



Parameter	Estimate	Standard-error	t Value	Pr > t
Intercept	11.04894679	1.69638849	6.51	<.0001
ba	0.32244569	0.02016993	15.99	<.0001
ba*ba	-0.00043001	0.00005654	-7.6	<.0001

Ponderosa pine - BA to CC

Data for ponderosa pine (n=1798) included plots where the QMD of stands ranged from 1.5" DBH to 31.5" DBH (predominantly 5.5" to 13.5" DBH) at 50% host type or greater (Figure C3). The plot of all points is shown in Figure C4 with predictive relationship described by the equation:

Canopy Cover of PP = $3.042580 + (0.339764 \cdot BA) + (-0.0003997 \cdot BA^2)$ ($R^2=82\%$; $p<0.001$) (Table C2)

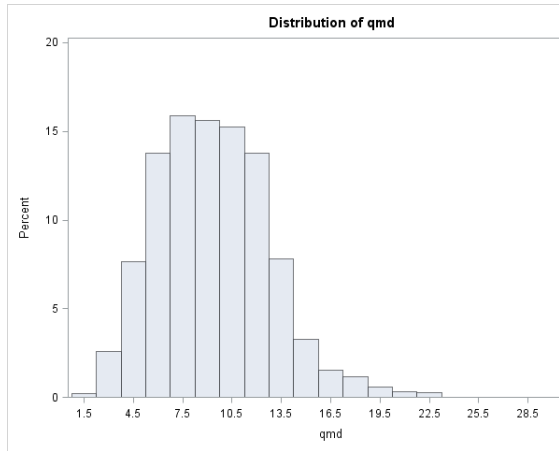


Figure C3 Distribution of quadratic mean diameters of data plots.

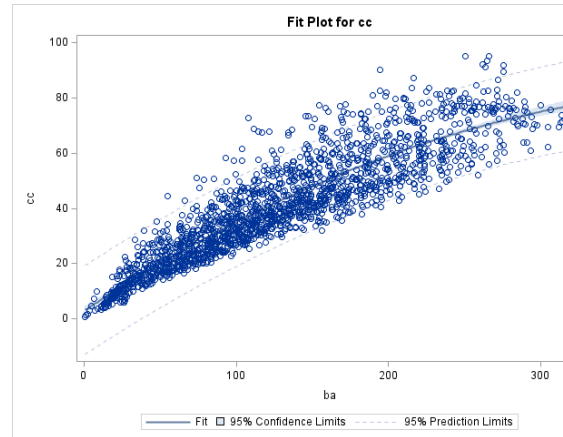


Figure C4. Distribution of data points, best-fit curve, and 95% prediction limits.

Table C2. Plot and parameters for equation describing the relationship between canopy cover and basal area.

CC				
Parameter	Estimate	Standard-error	t Value	Pr > t
Intercept	3.042580267	0.67394733	4.51	<.0001
ba	0.359764422	0.010391	34.62	<.0001
ba*ba	-0.000399748	0.00003498	-11.43	<.0001

APPENDIX D: 2016 AND NEWER VMAP (NEW) MODEL CRITERIA AND GIS QUERY LANGUAGE for Idaho Panhandle, Kootenai, Bitterroot, Lolo and most of the Beaverhead-Deerlodge National Forests

Information is provided for individual hazard ratings for the “Conservative and Limited” queries and the “Liberal and Complete” queries that rate all polygons designated as NOT RATED by the “Conservative and Limited”. The text in red provides the ARC GIS language queries that match the criteria provided by FHP entomologists.

DOUGLAS-FIR BEETLE (DFB_HAZ; DFB_HAZ_CODE)

DFB models were done for the fire salvage efforts and will not be changed. Insufficient information on canopy cover conversion, and field observations suggest that age (size is closest surrogate) is of primary importance.

DOUGLAS-FIR BEETLE – CONSERVATIVE & LIMITED

HIGH (303): PSME >=50% BAwtDBH >=14”

PERCENT_PSME >= 50 AND AVEDBH >=14

MOD (302): PSME >=50% BAwtDBH 10-13.9”

(PERCENT_PSME >= 50 AND (AVEDBH >=10 AND AVEDBH <14))

LOW (301): PSME >=50% BAwtDBH <10”

(PERCENT_PSME >= 50 AND (AVEDBH < 10))

NON-FOREST (304): Life Form not TREED (4000)

Lifeform <> 4000

All else is NOT RATED (900)

DOUGLAS-FIR BEETLE – LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

MOD (402): PSME 10-49% BAwtDBH >=10”

((PERCENT_PSME >= 10 and PERCENT_PSME < 50) AND AVEDBH >= 10)

LOW (401) PSME 10-49% BAwtDBH <10”

((PERCENT_PSME >= 10 and PERCENT_PSME < 50) AND AVEDBH < 10)

VERYLOW (400): PSME <10% but stand is not NON-FOREST

((PERCENT_PSME < 10) and LIFEFORM =4000)

SPRUCE BEETLE HAZARD¹ (SB_HAZ; SB_HAZ_CODE)

[illegible]

¹ Canopy cover equivalents for TBA thresholds of 100 BA and 150 BA were estimated as 35% and 45% CC, respectively, similar to pine values.

SPRUCE BEETLE - CONSERVATIVE & LIMITED

High (303)

((((PERCENT_PIEN >= 65) AND (AVEDBH >= 16) AND (CANOPYPERC >= 35)) OR ((PERCENT_PIEN >= 65) AND (AVEDBH >= 12 AND AVEDBH < 16) AND (CANOPYPERC >= 45)) OR ((PERCENT_PIEN >= 50 AND PERCENT_PIEN < 65) AND (AVEDBH >= 16) AND (CANOPYPERC >= 45)))

Mod (302)

((((PERCENT_PIEN >= 65) AND (AVEDBH >= 16) AND (CANOPYPERC < 35)) OR ((PERCENT_PIEN >= 65) AND (AVEDBH >= 12 AND AVEDBH < 16) AND (CANOPYPERC < 45)) OR ((PERCENT_PIEN >= 50) AND (AVEDBH < 12) AND (CANOPYPERC >= 35)) OR ((PERCENT_PIEN >= 50 AND PERCENT_PIEN < 65) AND (AVEDBH >= 16) AND (CANOPYPERC < 45)) OR ((PERCENT_PIEN >= 50 AND PERCENT_PIEN < 65) AND (AVEDBH >= 12 AND AVEDBH < 16))))

Low (301)

((PERCENT_PIEN >= 50) AND (AVEDBH < 12) AND (CANOPYPERC < 35))

NON-FOREST (304): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

SPRUCE BEETLE - LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

Mod (402)

((PERCENT_PIEN >= 10 AND PERCENT_PIEN < 50) AND (AVEDBH >= 12) AND (CANOPYPERC >= 35))

Low (401)

((((PERCENT_PIEN >= 10 AND PERCENT_PIEN < 50) AND (AVEDBH >= 12) AND (CANOPYPERC < 35)) OR ((PERCENT_PIEN >= 10 AND PERCENT_PIEN < 50) AND (AVEDBH < 12))))

Very Low (400)

((PERCENT_PIEN < 10) and LIFEFORM =4000)

PINE BARK BEETLES in ALL PINES COMBINED (COMBO)¹ (COMBO_MPB_HAZ; COMBO_MPB_HAZ_CODE)

[illegible]

¹lower threshold of 25% of total BA in host puts one potentially high hazard stand type into 400 codes; canopy cover thresholds based on lodgepole pine equivalence (Appendix C)

PINE BARK BEETLES in ALL PINES COMBINED (COMBO)– CONSERVATIVE & LIMITED *(PIMO rare in VMap and not included)*

High (303) (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH >= 8) AND (CANOPYPERC >= 34) OR ((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH >= 6 AND AVEDBH < 8) AND (CANOPYPERC >= 44))

Mod (302) (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH >= 8) AND (CANOPYPERC < 34) OR ((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH >= 6 AND AVEDBH < 8) AND (CANOPYPERC < 44) OR ((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH < 6) AND (CANOPYPERC >= 34))

Low (301) (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO) >=50) AND (AVEDBH < 6) AND (CANOPYPERC < 34))

NON-FOREST (304): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

PINE BARK BEETLES in ALL PINES COMBINED (COMBO)– COMPLETE AND LIBERAL

High (403) ((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=25) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO <50)) AND (AVEDBH >= 8) AND (CANOPYPERC >= 44))

Mod (402) (((((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=25) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 50)) AND (AVEDBH >= 8) AND (CANOPYPERC < 44)) OR (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=25) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 50)) AND (AVEDBH >= 6 AND AVEDBH < 8)) OR (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=25) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 50)) AND (AVEDBH < 6) AND (CANOPYPERC >= 34)) OR (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=10) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 25)) AND (AVEDBH >= 6) AND (CANOPYPERC >= 34)))

Low (401) (((((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=25) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 50)) AND (AVEDBH < 6) AND (CANOPYPERC < 34)) OR (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=10) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 25)) AND (AVEDBH >= 6) AND (CANOPYPERC < 34)) OR (((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO >=10) AND (PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 25)) AND (AVEDBH < 6)))

Very Low (400) ((PERCENT_PIAL + PERCENT_PICO + PERCENT_PIFL2 + PERCENT_PIPO < 10) AND (LIFEFORM =4000))

MOUNTAIN PINE BEETLE in LODGEPOLE PINE¹ (MPB_LP_HAZ; MPB_LP_HAZ_CODE)

[illegible]

¹lower threshold of 25% of total BA in host puts one potentially high hazard stand type into 400 codes; canopy cover thresholds based on lodgepole pine equivalence (Appendix C); additional requirement of a BA threshold of 250 (=65% CC) added

MOUNTAIN PINE BEETLE in LODGEPOLE PINE – CONSERVATIVE & LIMITED

High (303)

((((PERCENT_PICO >=50) AND (AVEDBH >= 8) AND (CANOPYPERC >= 34 AND CANOPYPERC < 65))
OR ((PERCENT_PICO >=50) AND (AVEDBH >= 7 AND AVEDBH < 8) AND (CANOPYPERC >= 44 AND CANOPYPERC < 65)))

Mod (302)

((((PERCENT_PICO >=50) AND (AVEDBH >= 8) AND (CANOPYPERC < 34 OR CANOPYPERC >= 65))
OR ((PERCENT_PICO >=50) AND (AVEDBH >= 7 AND AVEDBH < 8) AND (CANOPYPERC < 44 OR CANOPYPERC >= 65))
OR ((PERCENT_PICO >=50) AND (AVEDBH < 7) AND (CANOPYPERC >= 34 AND CANOPYPERC < 65)))

Low (301)

PERCENT_PICO >= 50 AND AVEDBH <7 AND (CANOPYPERC <34 OR CANOPYPERC >= 65)

NON-FOREST (304): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

MOUNTAIN PINE BEETLE in LODGEPOLE PINE – LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

High (403)

(((((PERCENT_PICO >=25) AND (PERCENT_PICO < 50)) AND (AVEDBH >= 8) AND (CANOPYPERC >= 44 AND CANOPYPERC < 65))

Mod (402)

(((((PERCENT_PICO >=25) AND (PERCENT_PICO < 50)) AND (AVEDBH >= 8) AND (CANOPYPERC < 44 OR CANOPYPERC >= 65))
OR (((PERCENT_PICO >=25) AND (PERCENT_PICO < 50)) AND (AVEDBH >= 7 AND AVEDBH < 8))
OR (((PERCENT_PICO >=25) AND (PERCENT_PICO < 50)) AND (AVEDBH < 7) AND (CANOPYPERC >= 34 AND CANOPYPERC <65))
OR (((PERCENT_PICO >=10) AND (PERCENT_PICO < 25)) AND (AVEDBH >= 7) AND (CANOPYPERC >= 34 AND CANOPYPERC < 65)))

Low (401)

(((((PERCENT_PICO >=25) AND (PERCENT_PICO < 50)) AND (AVEDBH < 7) AND (CANOPYPERC < 34 OR CANOPYPERC >= 65))
OR (((PERCENT_PICO >=10) AND (PERCENT_PICO < 25)) AND (AVEDBH >= 7) AND (CANOPYPERC < 34 OR CANOPYPERC >= 65))
OR (((PERCENT_PICO >=10) AND (PERCENT_PICO < 25)) AND (AVEDBH < 7)))

Very Low (400) ((PERCENT_PICO < 10) and LIFEFORM =4000)

MOUNTAIN PINE BEETLE in WHITEBARK PINE and LIMBER PINE¹ (MPB_WBP_HAZ; MPB_WBP_HAZ_CODE)

NOTE: This hazard rating was changed from the original Randall and others (2019) to contain only one threshold for stand density (noted in blue). In place of divisions at 40 and 45 ft² BA (Table below), corresponding roughly to 23% and 25% CC for lodgepole pine or 17% and 18% for ponderosa pine, a single threshold of 20% canopy cover was used.

Hazard Criteria for Mountain Pine Beetle in Whitebark and Limber Pines^a

Criteria	Attribute	Low (.5)	Moderate (2)	High (3)
A	QMD of whitebark and limber pine $\geq 5''$ DBH	$< 7''$	$7'' \leq \text{QMD} < 12''$	$\geq 12''$
B	BA all species (ft ² /acre)	$< 40 \text{ ft}^2/\text{acre}$	$40 \leq \text{BA} < 45 \text{ ft}^2/\text{acre}$	$\geq 45 \text{ ft}^2/\text{acre}$
		$< 40 - 45 \text{ ft}^2/\text{acre}$	(Dropped)	$\geq 40 - 45 \text{ ft}^2/\text{acre}$
C	% of total BA that is whitebark and limber pine $\geq 5''$ DBH	$< 25\%$	$25\% \leq \% \text{ BA} < 50\%$	$\geq 50\%$

Directly Calculated Hazard Values and Hazard Rating Multiplicative Index

Hazard	Calculated Values	Hazard Rating
Extremely Low	0	0
Low	< 2	1, L
Moderate ¹	2-17	2, M
High ¹	≥ 18	3, H

^aFor stands/plots with $< 40 \text{ ft}^2$ BA, hazard is rated as 'Low' due to reduced bark beetle habitat suitability at low stand densities

Note also, that in the final tools used to apply hazard to R1-VMaP, limber pine is included only for B-D. Other Forests using post-2016 VMap products have not or very little limber so only whitebark was used.

[illegible]

¹ lower threshold of 25% of total BA in host puts one potentially high hazard stand type into 400 codes; Liberal & Complete” rating not provided in old VMap product

MOUNTAIN PINE BEETLE in WHITEBARK PINE (and LIMBER) – CONSERVATIVE & LIMITED

High (303)

((((PERCENT_PIAL + PERCENT_PIFL2) >=50) AND (AVEDBH >= 7) AND (CANOPYPERC >= 20))

Mod (302)

((((PERCENT_PIAL + PERCENT_PIFL2) >=50) AND (AVEDBH >= 7) AND (CANOPYPERC < 20)
OR ((PERCENT_PIAL + PERCENT_PIFL2) AND (AVEDBH < 7) AND (CANOPYPERC >= 20))

Low (301)

((((PERCENT_PIAL + PERCENT_PIFL2) >=50) AND (AVEDBH < 7) AND (CANOPYPERC < 20))

NON-FOREST(304): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

MOUNTAIN PINE BEETLE in WHITEBARK PINE (and LIMBER) – LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

High (403)

((((PERCENT_PIAL + PERCENT_PIFL2 >= 25) and (PERCENT_PIAL + PERCENT_PIFL2 <50)) AND (AVEDBH >=12) AND (CANOPYPERC >= 20))

Mod (402)

(((((PERCENT_PIAL + PERCENT_PIFL2 >=25) AND (PERCENT_PIAL + PERCENT_PIFL2 < 50)) AND (AVEDBH >= 12) AND (CANOPYPERC < 20))
OR (((PERCENT_PIAL + PERCENT_PIFL2 >=25) AND (PERCENT_PIAL + PERCENT_PIFL2 < 50)) AND (AVEDBH >= 7 AND AVEDBH < 12))
OR (((PERCENT_PIAL + PERCENT_PIFL2 >=25) AND (PERCENT_PIAL + PERCENT_PIFL2 < 50)) AND (AVEDBH < 7) AND (CANOPYPERC >= 20))
OR (((PERCENT_PIAL + PERCENT_PIFL2 >=10) AND (PERCENT_PIAL + PERCENT_PIFL2 < 50)) AND (AVEDBH >= 7) AND (CANOPYPERC >= 20))))

Low (401)

(((((PERCENT_PIAL + PERCENT_PIFL2 >=25) AND (PERCENT_PIAL + PERCENT_PIFL2 < 50)) AND (AVEDBH < 7) AND (CANOPYPERC < 20))
OR (((PERCENT_PIAL + PERCENT_PIFL2 >=10) AND (PERCENT_PIAL + PERCENT_PIFL2 < 25)) AND (AVEDBH >= 7) AND (CANOPYPERC < 20))
OR (((PERCENT_PIAL + PERCENT_PIFL2 >=10) AND (PERCENT_PIAL + PERCENT_PIFL2 < 25)) AND (AVEDBH < 7))))

Very Low (400) ((PERCENT_PIAL + PERCENT_PIFL2 < 10) and LIFEFORM =4000)

PINE BARK BEETLES (MPB, WPB, Ips etc.) in PONDEROSA PINE¹ (MPB_WBP_PP_HAZ; MPB_WBP_PP_HAZ_CODE)

Note that this model has been superseded by the Updated Hazard Rating for Ponderosa Pine (Appendix F)

HOST:				%HOST			QMD (in) as BAwtDBH			TBA as CC						
PIPO				LOW cut	40		LOW cut	6		LOW cut	30					
				HIGH cut	65		HIGH cut	10		HIGH cut	40					
High(303)																
		Percent BA	PIPO	>=	65		AND	BAwtDBH	>=	10			AND	%CanopyCover	>=	30
			OR					BAwtDBH	=	6	to	9.9		%CanopyCover	>=	40
	OR	Percent BA	PIPO	=	40	to	64.9	AND	BAwtDBH	>=	10		AND	%CanopyCover	>=	40
Mod(302)																
		Percent BA	PIPO	>=	65		AND	BAwtDBH	>=	10			AND	%CanopyCover	<	30
			OR					BAwtDBH	=	6	to	9.9		%CanopyCover	<	40
	OR	Percent BA	PIPO	>=	40			BAwtDBH	<	6				%CanopyCover	>=	30
	OR	Percent BA	PIPO	=	40	to	64.9	AND	BAwtDBH	>=	10		AND	%CanopyCover	<	40
			OR					BAwtDBH	=	6	to	9.9		%CanopyCover	=	ALL CC%
Low(301)																
		Percent BA	PIPO	>=	40		AND	BAwtDBH	<	6			AND	%CanopyCover	<	30
Mod(402)																
		Percent BA	PIPO	=	10	to	39.9	AND	BAwtDBH	>=	6		AND	%CanopyCover	>=	30
Low(401)																
		Percent BA	PIPO	=	10	to	39.9	AND	BAwtDBH	>=	6		AND	%CanopyCover	<	30
			OR					BAwtDBH	<	6				%CanopyCover	=	ALL CC%
VeryLow(400)																
		Percent BA	PIPO	<	10			BAwtDBH	=	ALL				%CanopyCover	=	ALL CC%

¹host requirement for “Conservative & Limited” codes [300 codes] dropped to 40%; canopy cover thresholds based on ponderosa pine equivalence (Appendix C); “Liberal & Complete” rating not provided in old VMap product

PINE BARK BEETLES (MPB, WPB, etc.) in PONDEROSA PINE – CONSERVATIVE & LIMITED

High (303)

((((PERCENT_PIPO >= 65) AND (AVEDBH >= 10) AND (CANOPYPERC >= 30)) OR ((PERCENT_PIPO >= 65) AND (AVEDBH >= 6 AND AVEDBH < 10) AND (CANOPYPERC >= 40)) OR ((PERCENT_PIPO >= 40 AND PERCENT_PIPO < 65) AND (AVEDBH >= 10) AND (CANOPYPERC >= 40)))

Mod (302)

((((PERCENT_PIPO >= 65) AND (AVEDBH >= 10) AND (CANOPYPERC < 30)) OR ((PERCENT_PIPO >= 65) AND (AVEDBH >= 6 AND AVEDBH < 10) AND (CANOPYPERC < 40)) OR ((PERCENT_PIPO >= 40) AND (AVEDBH < 6) AND (CANOPYPERC >= 30)) OR ((PERCENT_PIPO >= 40 AND PERCENT_PIPO < 65) AND (AVEDBH >= 10) AND (CANOPYPERC < 40)) OR ((PERCENT_PIPO >= 40 AND PERCENT_PIPO < 65) AND (AVEDBH >= 6 AND AVEDBH < 10)))

Low (301) ((PERCENT_PIPO >= 40) AND (AVEDBH < 6) AND (CANOPYPERC < 30))

NON-FOREST (304): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

PINE BARK BEETLES (MPB, WPB, etc.) in PONDEROSA PINE – LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

Mod (402)

((PERCENT_PIPO >= 10 AND PERCENT_PIPO < 40) AND (AVEDBH >= 6) AND (CANOPYPERC >= 30))

Low (401)

((((PERCENT_PIPO >= 10 AND PERCENT_PIPO < 40) AND (AVEDBH >= 6) AND (CANOPYPERC < 30)) OR ((PERCENT_PIPO >= 10 AND PERCENT_PIPO < 40) AND (AVEDBH < 6)))

Very Low (400) ((PERCENT_PIPO < 10) and LIFEFORM =4000)

MOUNTAIN PINE BEETLE in WESTERN WHITE PINE

This model was not created for the 2016 and newer VMAP products. Within the R1 Summary Database for the forests with the updated “NEW” VMap products, only 4 plots were identified as having a DOM6040 of PIMO3 or PIMO3-IMIX. Looking at all 1822 plots on these forests, there were no plots rated as having a HIGH hazard for MPB in PIMO; 47 plots were rated as having MODERATE hazard.

APPENDIX E: PRE-2016 VMAP (OLD) MODEL CRITERIA AND GIS QUERY LANGUAGE for Custer, Flathead, Gallatin, Helena, Lewis and Clark, Nez Perce, and a small portion of the Beaverhead-Deerlodge National Forests

Information is provided for individual hazard ratings for the “Conservative and Limited” queries and the “Liberal and Complete” queries that rate all polygons designated as NOT RATED by the “Conservative and Limited”. The text in red provides the ARC GIS language queries that match the criteria provided by FHP entomologists.

DOUGLAS-FIR BEETLE (DFB_HAZ; DFB_HAZ_CODE)

DOUGLAS-FIR BEETLE - CONSERVATIVE & LIMITED

DFB models were done for the fire salvage efforts and will not be changed. Insufficient information on canopy cover conversion, and field observations suggest that age (size is closest surrogate) is of primary importance.

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH (103):	Dom40=PSME	Size= 15+	CC=all
((DOM_MID_40 = 8025) AND (TREESIZE = 4400 or TREESIZE = 4500))			
MOD (102):	Dom40=PSME	Size= 10-14.9	CC=all
((DOM_MID_40 = 8025) AND (TREESIZE = 4300))			
LOW (101):	Dom40=PSME	Size= 0-4.9, 5-9.9	CC=all
((DOM_MID_40 = 8025) AND ((TREESIZE = 4100) OR (TREESIZE = 4200)))			
NON-FOREST (104):	Life Form not TREED (4000)		
LIFEFORM <> 4000			

All else is NOT RATED (900)

DOUGLAS-FIR BEETLE - LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED query set to give value to NON-RATED polys)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
MOD (202):	Dom40= IMIX*, ABGR, or TMIX*	Size= 10-14.9, 15+	CC=all
((DOM_MID_40 = 8035 OR DOM_MID_40 = 8400 OR DOM_MID_40 = 8500) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500))			
LOW (201):	Dom40=IMIX, ABRG, or TMIX	Size= 0-4.9, 5-9.9	CC=all
((DOM_MID_40 = 8035 OR DOM_MID_40 = 8400 OR DOM_MID_40 = 8500) AND (TREESIZE = 4100 OR TREESIZE = 4200))			
VERY LOW (200):	Dom40 <u>not</u> = PSME, ABGR, IMIX, TMIX	Size= all	CC=all
((DOM_MID_40 <> 8025 AND DOM_MID_40 <> 8035 AND DOM_MID_40 <> 8400 AND DOM_MID_40 <> 8500) AND (LIFEFORM = 4000))			

SPRUCE BEETLE (SB_HAZ; SB_HAZ_CODE)

SPRUCE BEETLE – CONSERVATIVE & LIMITED

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH (103):	Dom6040=PIEN	Size >= 15+	CC=60+
(DOM_GRP_6040 = 8070 AND (TREESIZE = 4400 or TREESIZE = 4500) AND TREECANOPY = 4004)			
MOD (102):	Dom6040=PIEN	Size >= 15+	CC=40-60
		Size= 10-14.9	CC= 60+
	Dom6040=pien-<IMIX/TMIX/HMIX>	Size >= 15+	CC=60+
	(((DOM_GRP_6040 = 8070) AND (TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4003)) OR ((DOM_GRP_6040 = 8070) AND (TREESIZE = 4300) AND (TREECANOPY = 4004)) OR ((DOM_GRP_6040 = 8073 OR DOM_GRP_6040 = 8074) AND (TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4004)))		
LOW (101):	Dom6040=PIEN	Size= >= 15+	CC= <40%
		Size= 10-14.9	CC= <60%
		Size= 0-4.9, 5-9.9	CC=all
	Dom6040=pien-<IMIX/TMIX/HMIX>	Size >= 15+	CC <60
		Size= 0-4.9, 5-9.9, 10-14.9	CC=all
(((DOM_GRP_6040 = 8070) AND (TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002)) OR ((DOM_GRP_6040 = 8070) AND (TREESIZE = 4300) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003)) OR ((DOM_GRP_6040 = 8070) AND (TREESIZE = 4100 OR TREESIZE = 4200)) OR ((DOM_GRP_6040 = 8073 OR DOM_GRP_6040 = 8074) AND (TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003)) OR ((DOM_GRP_6040 = 8073 OR DOM_GRP_6040 = 8074) AND (TREESIZE = 4300 OR TREESIZE = 4100 OR TREESIZE = 4200)))			
NON-FOREST (104):	Life Form not TREED (4000) LIFEFORM <> 4000		
All else is NOT RATED (900)			

SPRUCE BEETLE - LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
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MOD (202): Dom6040=ABLA, ABLA-TMIX, PICO-IMIX, PICO-TMIX, TMIX, PIAL, PIAL-IMIX, or PIAL-TMIX

Size=10-15, 15+

CC=40-60, 60+

((DOM_GRP_6040 = 8060 OR DOM_GRP_6040 = 8064 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054 OR DOM_GRP_6040 = 8500 OR DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4003 OR TREECANOPY = 4004))

LOW (201): Dom6040=ABLA or ABLA-TMIX or PICO-IMIX or PICO-TMIX or TMIX

Size= 10-15, 15+

CC <40

Size=<10"

CC=all

Dom6040= PIAL, PIAL-IMIX, PIAL-TMIX

Size= 10-15, 15+

CC =25-39

Size= 5-9.9"

CC=all

((DOM_GRP_6040 = 8060 OR DOM_GRP_6040 = 8064 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054 OR DOM_GRP_6040 = 8500) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4002 OR TREECANOPY = 4001))
 OR ((DOM_GRP_6040 = 8060 OR DOM_GRP_6040 = 8064 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054 OR DOM_GRP_6040 = 8500) AND (TREESIZE = 4100 OR TREESIZE = 4200))
 OR ((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4002))
 OR ((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) AND (TREESIZE = 4200)))

VERY LOW (200):

Dom6040= PIAL, PIAL-IMIX, PIAL-TMIX

Size= 10-15, 15+

CC <25

Size= 0-5"

CC=all

Plus everything else: Dom6040 is TREED but NOT

ABLA, ABLA-TMIX, PICO-IMIX, PICO-TMIX, TMIX, PIAL, PIAL-IMIX, or PIAL-TMIX

Size=all

CC=all

((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500) AND (TREECANOPY = 4001))

OR ((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) AND (TREESIZE = 4100))

OR ((DOM_GRP_6040 <> 8060 AND DOM_GRP_6040 <> 8064 AND DOM_GRP_6040 <> 8053 AND DOM_GRP_6040 <> 8054 AND DOM_GRP_6040 <> 8500 AND DOM_GRP_6040 <> 8120 AND DOM_GRP_6040 <> 8123 AND DOM_GRP_6040 <> 8124 AND DOM_GRP_6040 <> 8070 AND DOM_GRP_6040 <> 8073 AND DOM_GRP_6040 <> 8074) AND (LIFEFORM = 4000)))

***PINE BARK BEETLES in ALL PINES COMBINED (COMBO) (COMBO_MPB_HAZ;
COMBO_MPB_HAZ_CODE)***

PINE BARK BEETLES in ALL PINES COMBINED (COMBO) CONSERVATIVE & LIMITED

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH (103):	PIAL, PICO, PIFL2, PIMO3 , PIPO, <pine species> - IMIX, TMIX, HMIX	Size=10-14.9, 15+	CC=25-39, 40-60, 60+

((((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) OR
(DOM_GRP_6040 = 8050 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) OR (DOM_GRP_6040
= 8150 OR DOM_GRP_6040 = 8153) OR (DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR
DOM_GRP_6040 = 8014)) AND (TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE = 4500) AND
(TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

MOD (102):	PIAL, PICO, PIFL2, PIMO3 , PIPO, <pine species> - IMIX, TMIX, HMIX	Size=5-9.9	CC=25-39, 40-60, 60+
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Size=0-4.9 CC=40-60, 60+

(((((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) OR
(DOM_GRP_6040 = 8050 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) OR (DOM_GRP_6040
= 8150 OR DOM_GRP_6040 = 8153) OR (DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR
DOM_GRP_6040 = 8014)) AND (TREESIZE = 4200) AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR
TREECANOPY = 4004))

OR (((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) OR
(DOM_GRP_6040 = 8050 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) OR (DOM_GRP_6040
= 8150 OR DOM_GRP_6040 = 8153) OR (DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR
DOM_GRP_6040 = 8014)) AND (TREESIZE = 4100) AND (TREECANOPY = 4003 OR TREECANOPY = 4004)))

LOW (101):	PIAL, PICO, PIFL2, PIMO3 , PIPO, <pine species> - IMIX, TMIX, HMIX	Size= 5-9.9, 10-14.9, 15+	CC <25
		Size=0-4.9	CC= 0-9, 10-24, 25-39

(((((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) OR
(DOM_GRP_6040 = 8050 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) OR (DOM_GRP_6040
= 8150 OR DOM_GRP_6040 = 8153) OR (DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR
DOM_GRP_6040 = 8014)) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 or TREESIZE =
4500) AND (TREECANOPY = 4001))

OR (((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124) OR
(DOM_GRP_6040 = 8050 OR DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) OR (DOM_GRP_6040
= 8150 OR DOM_GRP_6040 = 8153) OR (DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR
DOM_GRP_6040 = 8014)) AND (TREESIZE = 4100) AND (TREECANOPY = 4001 OR TREECANOPY = 4002)))

NON-FOREST (104): Life Form not TREED (4000) **LIFEFORM <> 4000**

All else is NOT RATED (900)

PINE BARK BEETLES in ALL PINES COMBINED (COMBO)– LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED set to give value to NON-RATED polys)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
MOD (202)	IMIX, ABLA-IMIX, PSME-IMIX TMIX, ABLA-TMIX, PIEN-TMIX <i>alphabetical = ABLA-IMIX, ABLA-TMIX, IMIX, PIEN-TMIX, PSME-IMIX, TMIX</i>	Size= 5-9.9, 10-14.9	CC >=25%

((DOM_GRP_6040 = 8400 OR DOM_GRP_6040 = 8500 OR DOM_GRP_6040 = 8063 OR DOM_GRP_6040 = 8064
OR DOM_GRP_6040 = 8074 OR DOM_GRP_6040 = 8023) AND (TREESIZE = 4200 OR TREESIZE = 4300)
AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

LOW (201)	IMIX, ABLA-IMIX, PSME-IMIX TMIX, ABLA-TMIX, PIEN-TMIX	Size= 5-9.9, 10-14.9	CC <25%
((DOM_GRP_6040 = 8400 OR DOM_GRP_6040 = 8500 OR DOM_GRP_6040 = 8063 OR DOM_GRP_6040 = 8064 OR DOM_GRP_6040 = 8074 OR DOM_GRP_6040 = 8023) AND (TREESIZE = 4200 OR TREESIZE = 4300) AND (TREECANOPY = 4001))			

VERY LOW (200)	IMIX, ABLA-IMIX, PSME-IMIX TMIX, ABLA-TMIX, PIEN-TMIX	Size= 0-4.9, 15+	CC=<any>
	<u>everything forested but not:</u> <pines>, <pine>-<mixes> IMIX, ABLA-IMIX, PSME-IMIX, TMIX, ABLA-TMIX, PIEN-TMIX	Size= <any>	CC=<any>

LIFEFORM = 4000 AND
(DOM_GRP_6040 NOT IN (8010, 8013, 8014, 8050, 8053, 8054, 8120, 8123, 8124, 8150, 8153, 8154, 8020, 8024, 8060, 8070, 8073) OR
(DOM_GRP_6040 IN (8400, 8500, 8063, 8023, 8064, 8074) AND TREESIZE NOT IN (4100, 4400, 4500))

MOUNTAIN PINE BEETLE in LODGEPOLE PINE (MPB_LP_HAZ; MPB_LP_HAZ_CODE)

MOUNTAIN PINE BEETLE in LODGEPOLE PINE – CONSERVATIVE & LIMITED

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH (103):	PICO	Size=10-14.9, 15+	CC=40-60, 60+
	PICO	Size=5-9.9	CC=60+
	PICO-<xMIX>	Size=10-14.9, 15+	CC=60+
<p>(((DOM_GRP_6040 = 8050) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4003 OR TREECANOPY = 4004))</p> <p>OR ((DOM_GRP_6040 = 8050) AND (TREESIZE = 4200) AND (TREECANOPY = 4004))</p> <p>OR ((DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4004)))</p>			
MOD (102):	PICO	Size=10-14.9, 15+	CC= <25, 25-39
	PICO	Size=5-9.9	CC= <25, 25-39, 40-60
	PICO-<xMIX>	Size=10-14.9, 15+	CC= <25, 25-39, 40-60
	PICO-<xMIX>	Size=5-9.9	CC= <25, 25-39, 40-60,
<p>60+</p> <p>(((DOM_GRP_6040 = 8050) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002))</p> <p>OR ((DOM_GRP_6040 = 8050) AND (TREESIZE = 4200) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003))</p> <p>OR ((DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003))</p> <p>OR ((DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) AND (TREESIZE = 4200)))</p>			
LOW (101):	PICO	Size=0-4.9	CC=all
	PICO-<xMIX>	Size=0-4.9	CC=all
<p>(((DOM_GRP_6040 = 8050) AND (TREESIZE = 4100))</p> <p>OR ((DOM_GRP_6040 = 8053 OR DOM_GRP_6040 = 8054) AND (TREESIZE = 4100)))</p>			
NON-FOREST (104):	Life Form not TREED (4000)		
	LIFEFORM <> 4000		

All else is NOT RATED (900)

MOUNTAIN PINE BEETLE in LODGEPOLE PINE – LIBERAL & COMPLETE

(add these to CONSERVATIVE & LIMITED to give value to NON-RATED polys)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
MOD (202)	TMIX and IMIX	5-9.9, 10-14.9, 15+	CC= <25, 25-39, 40-60, 60+
(=all)	PSME-IMIX	10-14.9	CC= <25, 25-39, 40-60, 60+
(=all)			

(((DOM_GRP_6040 = 8500 OR DOM_GRP_6040 = 8400) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500))
OR ((DOM_GRP_6040 = 8023) AND (TREESIZE = 4300)))

LOW (201)	TMIX and IMIX	0-4.9	CC= all
	PSME-IMIX	0-4.9, 5-9.9, and 15+	CC= all

(((DOM_GRP_6040 = 8500 OR DOM_GRP_6040 = 8400) AND (TREESIZE = 4100))
OR ((DOM_GRP_6040 = 8023) AND (TREESIZE = 4100 OR TREESIZE = 4200 OR TREESIZE = 4400 OR TREESIZE = 4500))))

VERY LOW (200): forested but Dom40 not= PICO, PICO-<xMIX>, TMIX, IMIX, PSME-IMIX
Size= all CC=all

LIFEFORM = 4000 AND (DOM_MID_40 <> 8055 AND DOM_MID_40 <> 8400 AND DOM_MID_40 <> 8500
AND DOM_MID_40 <> 8025)

***MOUNTAIN PINE BEETLE in WHITEBARK and LIMBER PINE (MPB_WBP_HAZ;
MPB_WBP_HAZ_CODE)***

**MOUNTAIN PINE BEETLE in WHITEBARK and LIMBER PINE – CONSERVATIVE & LIMITED
(ONLY)**

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH (103):	PIAL, PIAL-<mix>, PIFL, PIFL-<mix>	Size=10-14.9, 15+	CC= all

((DOM_GRP_6040 = 8120 OR DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124 OR DOM_GRP_6040 = 8150 OR DOM_GRP_6040 = 8153 OR DOM_GRP_6040 = 8154) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

MOD (102):	PIAL, PIAL-<mix>, PIFL, PIFL-<mix>	Size=5-9.9	CC = all
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((DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124 OR DOM_GRP_6040 = 8153 OR DOM_GRP_6040 = 8154) AND (TREESIZE = 4200) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

LOW (101):	PIAL, PIAL-<mix>, PIFL, PIFL-<mix>	Size= 0-4.9	CC=all
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((DOM_GRP_6040 = 8123 OR DOM_GRP_6040 = 8124 OR DOM_GRP_6040 = 8153 OR DOM_GRP_6040 = 8154) AND (TREESIZE = 4100) AND (TREECANOPY = 4001 OR TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

NON-FOREST (104): Life Form not TREED (4000)
LIFEFORM <> 4000

All else is NOT RATED (900)

Although ABLA, ABLA-TMIX, and TMIX have most of the remaining High and some Moderate plots within the “Not Rated” areas, the Very Low (non- or low-host) dominated. Thus, no additional rating of “Not Rated” areas will be done

PINE BARK BEETLES (MPB, WPB, Ips etc.) in PONDEROSA PINE¹ (MPB_WBP_PP_HAZ; MPB_WBP_PP_HAZ_CODE)

PINE BARK BEETLES (MPB, WPB, Ips etc.) in PONDEROSA PINE – CONSERVATIVE & LIMITED (ONLY)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
HIGH(103):	PIPO	Size=10-14.9, 15+	CC=25-39, 40-60, 60+

((DOM_GRP_6040 = 8010) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))

MOD(102):	PIPO	Size=10-14.9, 15+	CC= <25
	PIPO	Size=5-9.9	CC=25-39, 40-60, 60+
	PIPO-<mix>	Size=10-14.9, 15+	CC=40-60, 60+

((((DOM_GRP_6040 = 8010) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001))
OR ((DOM_GRP_6040 = 8010) AND (TREESIZE = 4200) AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))
OR ((DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4003 OR TREECANOPY = 4004))))

LOW(101):	PIPO	Size= 0-4.9	CC=all
		Size=5-9.9	CC=<25
	PIPO-<mix>	Size= 10-14.9, 15+	CC=<25, 25-39,
		Size= 0-4.9, 5-9.9	CC=all

((((DOM_GRP_6040 = 8010) AND (TREESIZE = 4100)
OR ((DOM_GRP_6040 = 8010) AND (TREESIZE = 4200) AND (TREECANOPY = 4001))
OR ((DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002))
OR ((DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4100 OR TREESIZE = 4200))))

NON-FOREST(104): Life Form not TREED (4000) LIFEFORM <> 4000

All else is NOT RATED (900)

Although PSME, PSME-IMIX has most of the remaining High and Moderate plots within the Not Rated areas, Very Low (non- or low-host) dominated ratings. Thus, no additional rating of Not Rated areas will be done.

MOUNTAIN PINE BEETLE in WESTERN WHITE PINE

No PIMO was found in FIA plots covering the Forests with only old VMap coverage so this rating was not completed. We suggest using the COMBO PINES model if you have PIMO In your stands and only have the older R1 VMap product.

APPENDIX F: UPDATED BARK BEETLE HAZARD RATINGS FOR PONDEROSA PINE Based on Stand Density Index

An analysis of empirical data from 17 research studies spanning 662 plots with 62,973 pines sampled in yellow pine stands indicate a strong relationship between probability of resistance to attack during bark beetle (mountain pine beetle, western pine beetle, Jeffery pine beetle) outbreaks and stand density index (SDI) (calculated with the SDI summation method from Stage 1968) (Egan et al. in press). This relationship was used to update the R1 hazard rating system for ponderosa pine from the one found in Randall and others (2018, 2019), and is applicable across the western U.S. The new system used probability of resistance vs. SDI values after stratifying research plots based on their exposure to severe or low-moderate levels of bark beetle population pressure. Then, two levels of resistance were calculated: high-level resistance (survivorship of $\geq 90\%$ pine stems $\geq 4"$ DBH) and moderate-level resistance (survivorship of $\geq 70\%$ pine stems $\geq 4"$ DBH) (see Fig. F1-a-d).

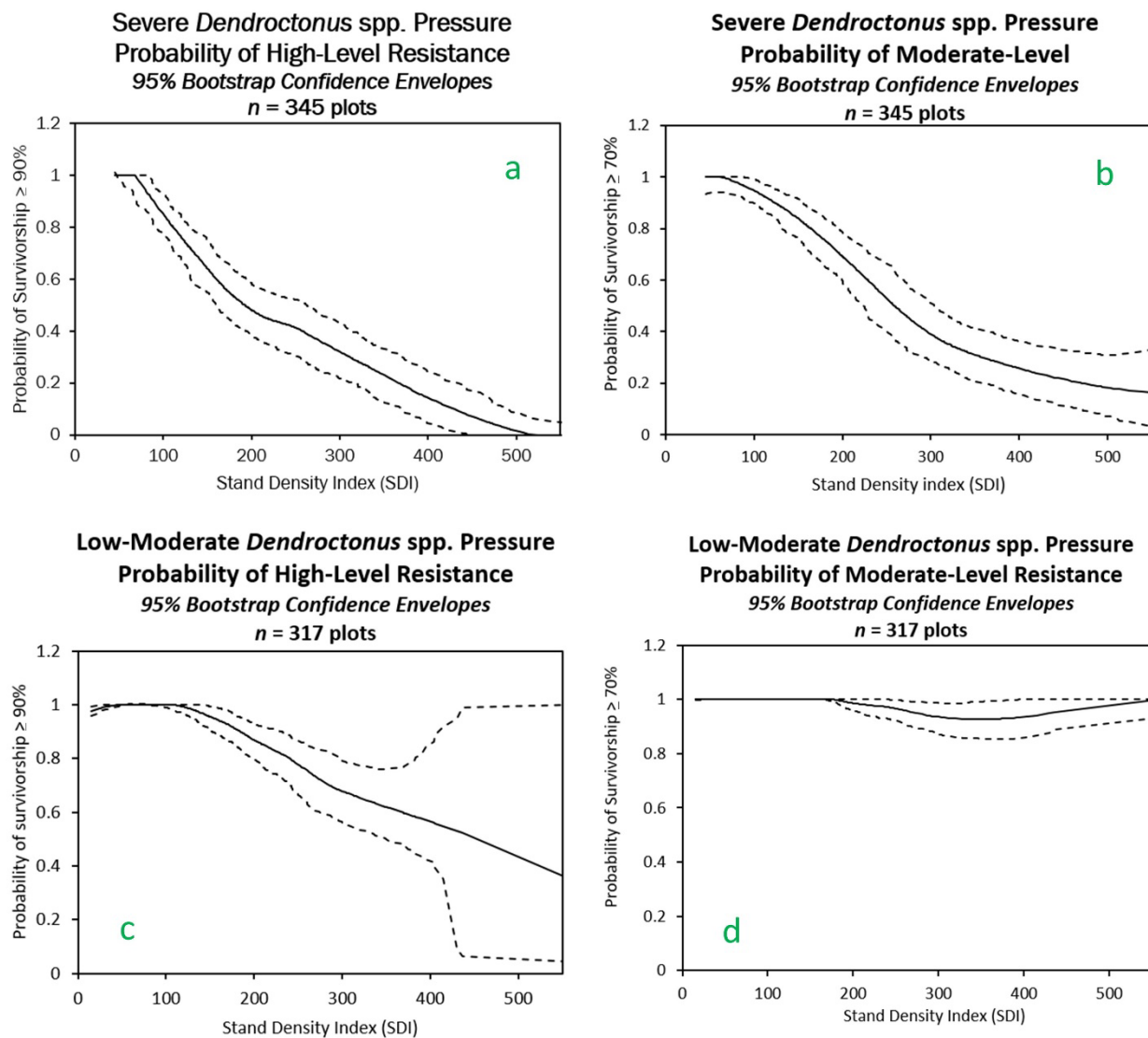


Figure F1. Graphs showing 90% tree survivorship (a and c) or 70% survivorship (b and d) under outbreak conditions with severe bark beetle pressure (a and b) or low to moderate outbreak pressure (c and d).

Using this resistance vs. SDI relationship, we determined the SDI thresholds where resistance was high ($\geq 85\%$ probability of $\geq 90\%$ survivorship), where it was moderate ($\geq 85\%$ probability of $\geq 70\%$ survivorship), and where stand density levels are not expected to provide any degree of resistance to beetle-attack ($\geq 85\%$ probability of $< 70\%$ survivorship of pine stems $\geq 4"$ DBH).

This hazard rating is separate for low-moderate vs. severe bark beetle pressure outbreak scenarios as susceptibility varies substantially based on short-term, ambient conditions that influence beetle population pressure and outbreak severity. The primary drivers of beetle pressure include 1) environmental factors including the severity and duration of stochastic drought events and 2) vegetation factors such as the landscape-scale abundance and distribution of pine reproductive habitat available to amplify bark beetle populations (Fettig et al. 2019; Restanio et al. 2019; Egan et al. in press).

It is recommended that end-users use the severe pressure scenario for most ponderosa pine stands within the Northern Region based on recent, and future-anticipated, drought severities. Conversely, the low-moderate pressure hazard ratings should be used for isolated pine stands that are surrounded by landscapes composed of other non-pine host (such as Douglas-fir) vegetation, or if stand conditions are low quality for bark beetle survival/reproduction.

The following hazard rating scheme were developed from these findings (Egan et al. [in press]):

BARK BEETLE HAZARD in PONDEROSA PINE – Severe Pressure (BB_PP_SDI_HAZ_S_PRES) using SDI

Evaluation Criteria:

1. If no PP is present (any size) but stand is “forested”, then VERY LOW SUSCEPTIBILITY (0)
2. If stand total BA (**TBA**) (*all species, all sizes*) is $< 40\text{ft}^2$, then LOW SUSCEPTIBILITY (1)
3. If **% host BA** (*defined as PP $\geq 5"$ DBH / stand total BA of all species and sizes*) is $< 25\%$, then LOW SUSCEPTIBILITY (1)
4. If PP “size” is $< 5"$ (*defined as BAwtDBH of PP of all sizes or QMD of PP $\geq 5"$ DBH*), then LOW SUSCEPTIBILITY (1)
5. If **% host BA** is $\geq 25\%$ and PP “size” is $\geq 5"$ DBH, then hazard assignment by SDI:
 - If SDI ≤ 100 (all species, all sizes), then LOW SUSCEPTIBILITY (1)
 - defined as having $\geq 85\%$ probability of $\leq 10\%$ mortality [or $\geq 90\%$ survivorship] during severe outbreak/BB population pressure
 - If $100 > \text{SDI} < 144$ (all species, all sizes), then MODERATE SUSCEPTIBILITY (2)
 - defined as having $\geq 85\%$ probability of $\leq 30\%$ mortality [or $\geq 70\%$ survivorship] during severe outbreak/BB population pressure
 - If SDI ≥ 144 (all species, all sizes), then HIGH SUSCEPTIBILITY (3)
 - defined as having $\geq 85\%$ probability of $> 30\%$ mortality [or $< 70\%$ survivorship] during severe outbreak/BB population pressure

BARK BEETLE HAZARD in PONDEROSA PINE – Low/Moderate Pressure (BB_PP_SDI_HAZ_LM_PRES) using SDI

Evaluation Criteria:

1. If no PP is present (any size) but “forested”, then VERY LOW SUSCEPTIBILITY (0)
2. If stand total BA (**TBA**) (*all species, all sizes*) is $< 40\text{ft}^2$, then LOW SUSCEPTIBILITY (1)
3. If **% host BA** (*defined as PP $\geq 5"$ DBH / stand total BA of all species and sizes*) is $< 25\%$, then LOW SUSCEPTIBILITY (1)

4. If PP “size” is <5” (calculated as BAwtDBH of PP of all sizes or QMD of PP >=5” DBH), then LOW SUSCEPTIBILITY (1)
5. If % host BA is >=25% and PP “size” is >=5”, then hazard assignment by SDI:
 - If SDI <= 208 (all species, all sizes), then LOW SUSCEPTIBILITY (1)
 - defined as having >=85% probability of <=10% mortality [or >=90% survivorship] during severe outbreak/BB population pressure
 - If SDI >208 (all species, all sizes), then MODERATE SUSCEPTIBILITY (2)
 - defined as having >=85% probability of <=30% mortality [or >=70% survivorship] during severe outbreak/BB population pressure
 - With Low/Mod beetle pressure no stands of PP (or other yellow pines) are HIGH SUSCEPTIBILITY (3) (i.e. none expected to have >=85% probability of >30% mortality [or <70% survivorship] during severe outbreak/BB population pressure)

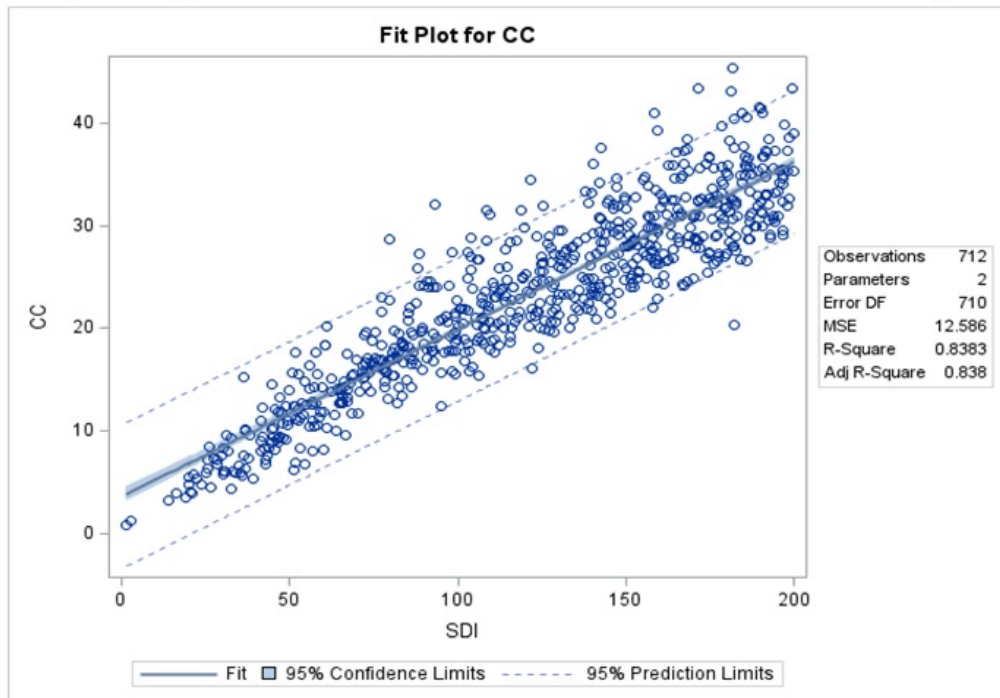
The simplified representation of this is:

- If no PP is present (any size) but “forested”, then VERY LOW SUSCEPTIBILITY (0)
- If % host BA (defined as PP>=5”DBH / stand total BA of all species and sizes) is >=25% and PP “size” (calculated as BAwtDBH of PP of all sizes or QMD of PP >=5” DBH) is >=5” and SDI (all species, all sizes) is > 208, then MODERATE SUSCEPTIBILITY (2)
- Otherwise, LOW SUSCEPTIBILITY (1)
- There is no HIGH SUSCEPTIBILITY (3) for the low-moderate pressure scenario!

Because VMap does not calculate SDI, we had to use the surrogate variable of canopy cover (CC). Canopy cover and SDI have a direct relationship so that canopy cover levels can be substituted into the above ratings. Forest Vegetation Simulator (FVS) output of canopy cover, adjusted for overlap (Zeide 1983; Crookston and Stage 1999) was derived from ponderosa pine 1/10th-acre plot sampled data from eastern Montana (Egan and Hayes 2016) was used to model the SDI-CC relationship for stands where >=50% of plot trees were ponderosa pine, 5” DBH or larger (Fig. F2).

Ponderosa pine canopy cover equivalents to the SDI thresholds in the Severe Pressure model were determined as 22% for an SDI of 100, and 27% for an SDI of 144. In the Low-Moderate Pressure model, ponderosa pine canopy cover of 37% was equivalent to an SDI of 208.

**Relationship of SDI to Canopy Cover under High-Pressure Outbreak Scenario
(SDI range of 150-300 used to show 100 SDI and 144 SDI thresholds)**



**Relationship of SDI to Canopy Cover under Low/Moderate-Pressure
(SDI range of 150-300 used to show the 208 SDI threshold)**

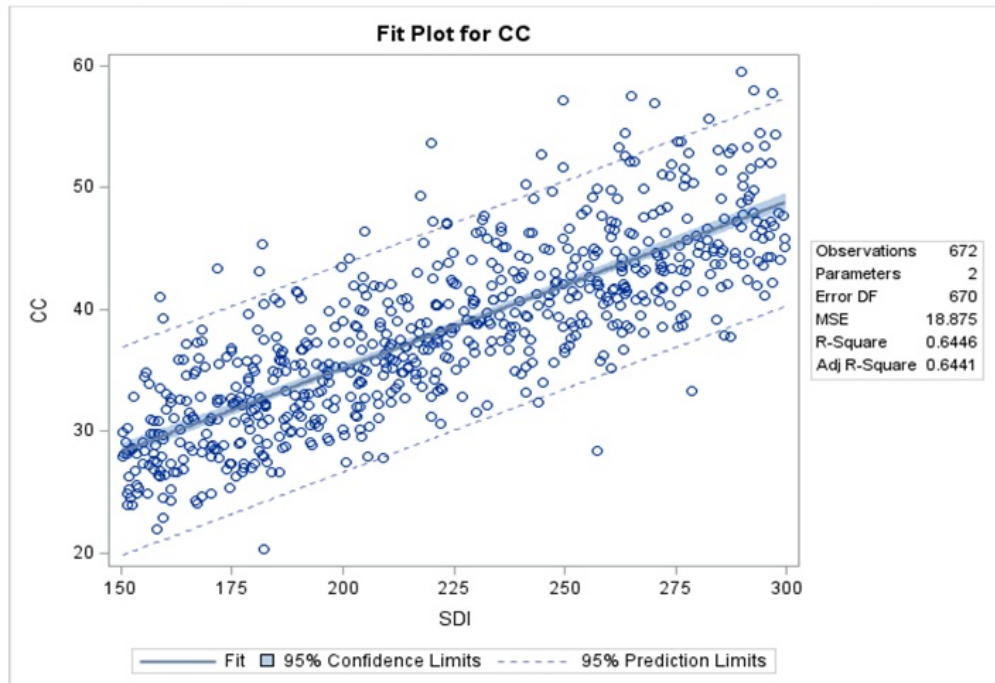


Figure F2. Relationship of SDI and canopy cover for Severe (left) and Low-Moderate (right) outbreak pressure scenarios.

Using these conversions, the hazard rating for bark beetles in ponderosa pine, for pre-2016 and post-2015 VMap products are as follows:

***BARK BEETLE HAZARD in PONDEROSA PINE – Severe Pressure (BB_PP_SDI_HAZ_S_PRES)
using Canopy Cover surrogate to SDI***

2016 and Newer VMap Product

CONSERVATIVE & LIMITED: Ponderosa pine dominated stands ($\geq 50\%$ PP)

NON-FOREST (504): Life Form not TREED (4000)

Lifeform \neq 4000

HIGH (503): PIPO $\geq 50\%$ BAwtDBH $\geq 5"$ CC $> 27\%$
(PERCENT_PIPO ≥ 50 AND ((AVEDBH ≥ 5) AND CANOPYPERC $> 27\%$))

MOD (502): PIPO $\geq 50\%$ BAwtDBH $\geq 5"$ CC 20-27%
(PERCENT_PIPO ≥ 50 AND ((AVEDBH ≥ 5) AND (CANOPYPERC $\geq 20\%$ AND CANOPYPERC $\leq 27\%$)))

LOW (501): PIPO $\geq 50\%$ BAwtDBH $\geq 5"$ CC $< 20\%$ (Note: $< 10\%$ CC is Non-Forest)
PIPO $\geq 50\%$ BAwtDBH $< 5"$ CC = any
((PERCENT_PIPO ≥ 50) AND (AVEDBH ≥ 5) AND (CANOPYPERC < 20)) OR
((PERCENT_PIPO ≥ 50) AND (AVEDBH < 5))

All else is NOT RATED (900)

LIBERAL & COMPLETE: Ponderosa pine $< 50\%$ of stand composition (add these to CONSERVATIVE & LIMITED set to give value to NON-RATED "900" polys)

MOD (602): PIPO 25-49% BAwtDBH $\geq 5"$ CC $> 27\%$
((PERCENT_PIPO ≥ 25 and PERCENT_PIPO < 50) AND (AVEDBH ≥ 5) AND (CANOPYPERC > 27))

LOW (601) PIPO 25-49% BAwtDBH $\geq 5"$ CC $< 27\%$ (Note: $< 10\%$ CC is Non-Forest)
PIPO 10-25% BAwtDBH $\geq 5"$ CC = any
PIPO 10-49% BAwtDBH $< 5"$ CC = any
((PERCENT_PIPO ≥ 25 and PERCENT_PIPO < 50) AND (AVEDBH ≥ 5) AND (CANOPYPERC < 27)) OR
((PERCENT_PIPO ≥ 10 and PERCENT_PIPO < 25) AND (AVEDBH ≥ 5)) OR
((PERCENT_PIPO ≥ 10 and PERCENT_PIPO < 50) AND (AVEDBH < 5))

VERY LOW (600): PIPO $< 10\%$ but stand is not NON-FOREST
((PERCENT_PIPO < 10) and (LIFEFORM = 4000))

Pre-2016 VMap Product

CONSERVATIVE & LIMITED: Ponderosa pine dominated stands (>=40% PP)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
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NON-FOREST (504):	Life Form not TREED (4000)		
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Lifeform <> 4000

HIGH (503):	Dom6040=PIPO (>=60%)	Size >=5"	CC >25%
((DOM_GRP_6040 = 8010) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))			

MOD (502):	Dom6040=PIPO-IMIX/TMIX/ HMIX (40-60%)	Size >=5"	CC >25%
((DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4002 OR TREECANOPY = 4003 OR TREECANOPY = 4004))			

LOW (501):	Dom6040=PIPO	Size >=5"	CC <25%
	Dom6040=PIPO-IMIX/TMIX/ HMIX	Size >=5"	CC <25%
	Dom6040=PIPO, PIPO-IMIX/TMIX/ HMIX	Size < 5"	CC = any
((DOM_GRP_6040 = 8010) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001)) OR			
((DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001)) OR			
((DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4100))			

LIBERAL & COMPLETE: Stands with limited ponderosa pine (<40% PP)

All other Dom6040 are LOW (601) (10-40% host) or VERY LOW (600) (<10% host) but data is insufficient to rate so "All else NOT RATED (900)"

***BARK BEETLE HAZARD in PONDEROSA PINE – Low-Moderate Pressure
(BB_PP_SDI_HAZ_LM_PRES) using Canopy Cover surrogate to SDI***

2016 and Newer VMap Product

CONSERVATIVE & LIMITED: Ponderosa pine dominated stands (>=50% PP)

NON-FOREST (704): Life Form not TREED (4000)

Lifeform <> 4000

HIGH: *(never reached under the low-moderate pressure outbreak scenario)*

MOD (702): PIPO >=50% BAwtDBH >=5" CC >36%
((PERCENT_PIPO >= 50) AND (AVEDBH >=5) AND (CANOPYPERC >36))

LOW (701): PIPO >=50% BAwtDBH >=5" CC <36% (Note: <10% CC is Non-Forest)
PIPO >=50% BAwtDBH <5" CC = any
((PERCENT_PIPO >= 50) AND (AVEDBH >=5) AND (CANOPYPERC <36)) OR
((PERCENT_PIPO >= 50) AND (AVEDBH <5"))

All else is NOT RATED (900)

*LIBERAL & COMPLETE: Ponderosa pine <50% of stand composition (add these to
CONSERVATIVE & LIMITED set to give value to NON-RATED "900" polys)*

MOD (802): PIPO 25-49% BAwtDBH >=5" CC >36%
((PERCENT_PIPO >= 25 and PERCENT_PIPO < 50) AND (AVEDBH >= 5) AND (CANOPYPERC >36))

LOW (801) PIPO 25-49% BAwtDBH >=5" CC <36% (Note: <10% CC is Non-Forest)
PIPO 10-25% BAwtDBH >=5" CC = any
PIPO 10-49% BAwtDBH <5" CC = any
((PERCENT_PIPO >= 25 and PERCENT_PIPO < 50) AND (AVEDBH >= 5) AND (CANOPYPERC <36)) OR
((PERCENT_PIPO >= 10 and PERCENT_PIPO < 25) AND (AVEDBH >= 5)) OR
((PERCENT_PIPO >= 10 and PERCENT_PIPO < 50) AND (AVEDBH < 5))

VERY LOW (800): PIPO <10% but stand is not NON-FOREST
((PERCENT_PIPO < 10) and (LIFEFORM =4000))

Pre-2016 VMap Product

CONSERVATIVE & LIMITED: Ponderosa pine dominated stands (>=40% PP)

HAZARD (CODE)	HOST LEVEL	TREE SIZE	CANOPY COVER
NON-FOREST (704):	Life Form not TREED (4000)		
Lifeform <> 4000			

HIGH: (never reached under the low-moderate pressure outbreak scenario)

MOD (702): Dom6040=PIPO, PIPO-IMIX/TMIX Size >=5" CC >=40%
((DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4003 OR TREECANOPY = 4004))

LOW (701): Dom6040=PIPO, PIPO-IMIX/TMIX Size >=5" CC <40%
Dom6040=PIPO, PIPO-IMIX/TMIX Size 0-5" CC = any
((DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4200 OR TREESIZE = 4300 OR TREESIZE = 4400 OR TREESIZE = 4500) AND (TREECANOPY = 4001 OR TREECANOPY = 4002)) OR
((DOM_GRP_6040 = 8010 OR DOM_GRP_6040 = 8013 OR DOM_GRP_6040 = 8014) AND (TREESIZE = 4100))

LIBERAL & COMPLETE: Stands with limited ponderosa pine (<40% PP)

All other Dom6040 are LOW(801) (10-40% host) or VERY LOW(800) (<10% host) but data is insufficient to rate so "All else NOT RATED (900)"

Literature Cited for Appendix F

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- Egan, J., Coleman, T., Fettig, C., Graham, J., Patterson, D., Jenne, J. et al. (in press). Managing yellow pine resistance to *Dendroctonus* spp. under stochastic and dynamic drought conditions throughout the western U.S. (Data analysis complete & available upon request. Manuscript in-preparation as of 5/20/19.)
- Fettig, C., Mortenson, L., Bulaon, B., Foulk, P. 2019. Tree mortality following drought in the central and southern Sierra Nevada, California, U.S. Forest Eco. and Mgmt. 432: 164-178.
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- Restaino, C., Young, D., Estes, B. Gross, S., Wuenschel, A., Meyer, M., Safford, H. 2019. Forest structure and climate mediate drought-induced tree mortality in forests of the Sierra Nevada, USA. *Ecological Applications*. DOI: [10.1002/eap.1902](https://doi.org/10.1002/eap.1902)
- Stage, Albert R. 1968. A tree-by-tree measure of site utilization for grand fir related to stand density index. Research Note INT-77. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 7 p.
- Zeide, Boris. 1983. The mean diameter for stand density index. *Canadian Journal of Forestry Research*. 13: 1023-1024.

APPENDIX G: PYTHON SCRIPT USED FOR HAZARD RATING OF 2016 AND NEWER VMAP: Idaho Panhandle, Kootenai, Bitterroot, Lolo and most of the Beaverhead-Deerlodge National Forests

```
# VMAP BD/BRT/LOLO/KOOT/IDP Forests Assign Insect Hazard Ratings based on Species Percent
# NR FHP Staff, NRGJ Jed Gregory and Chip Fisher
# 6-28-2019 Update for attribute name change from Renate Bush
#*****

# This script adds Insect Hazard attributes to VMap polygons and fills
# them in based on Percent Species Composition, AVEDBH, and CANOPYPERC.
# Please see THIS REPORT for details on how this script assigns the
# following bark beetle hazard ratings to all polygons:
# Douglas-fir Beetle
# Mountain Pine Beetle in PICO,
# Mountain Pine Beetle in Combined (all) Pines
# Mountain Pine Beetle, Western Pine Beetle and Ips spp. in PP
# Spruce Beetle
# Bark Beetle in PIPO Severe Pres
# Bark Beetle in PIPO Low-Mod Pres
#*****

# MUST HAVE A VMAP SPECIES PERCENT TABLE WITH FIELDS:
# FOREST_ID
# PERCENT_PSME
# PERCENT_PICO
# PERCENT_PIAL
# PERCENT_PIPO
# PERCENT_PIEN
#*****

# This script has one argument:
# VMap polygon layer
#####
import arcpy
from arcpy import env

##### SCRIPT ARGUMENTS
VMAP = arcpy.GetParameterAsText(0)
SPECPERCTBL = arcpy.GetParameterAsText(1)

arcpy.AddMessage("STARTING INSECT HAZARD ASSIGNMENTS FOR VMAP POLYGONS FROM BITLO OR
IPKNF DATASETS")

arcpy.AddMessage("CHECK FOR INSECT HAZARD ATTRIBUTES AND ADD IF NOT IN VMAP")
if len(arcpy.ListFields(VMAP,"DFB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "DFB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_LP_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "MPB_LP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_WBP_HAZ"))!=1:
```

```

    arcpy.AddField_management(VMAP, "MPB_WBP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"COMBO_MPB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "COMBO_MPB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_WPB_PP_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WPB_PP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"SB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "SB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_S_PRES"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_S_PRES", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_LM_PRES"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_LM_PRES", "TEXT", "", "", 10)

arcpy.AddMessage("CHECK FOR INSECT HAZARD CODE ATTRIBUTES AND ADD IF NOT IN VMAP")
if len(arcpy.ListFields(VMAP,"DFB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "DFB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_LP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_LP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_WBP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WBP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"COMBO_MPB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "COMBO_MPB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_WPB_PP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WPB_PP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"SB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "SB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_S_PRES_CODE"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_S_PRES_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_LM_PRES_CODE"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_LM_PRES_CODE", "SHORT")

# CREATE A DICTIONARY OF VMAP SPECIES PERCENT - NOTE the B-D tool also includes PIFL2
specperList =
["FOREST_ID","PERCENT_PSME","PERCENT_PICO","PERCENT_PIAL","PERCENT_PIPO","PERCENT_PIEN"]
specDict = {r[0]:(r[1:]) for r in arcpy.da.SearchCursor(SPECPERCTBL, specperList)}

arcpy.AddMessage("ASSIGN DOUGLAS-FIR BEETLE HAZARD")
flist = ["FOREST_ID","LIFEFORM","AVEDBH","CANOPYPERC","DFB_HAZ","DFB_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            percpsme = specDict[keyValue][0]
            avedbh = updateRow[2]
            canopyperc = updateRow[3]
            # DFB CONS-LIM HIGH 303
            if percpsme >= 50 and avedbh >= 14:
                updateRow[4] = "H"
                updateRow[5] = 303

```

```

# DFB CONS-LIM MOD 302
elif percpsme >= 50 and (avedbh >= 10 and avedb < 14):
    updateRow[4] = "M"
    updateRow[5] = 302

# DFB CONS-LIM LOW 301
elif percpsme >= 50 and avedb < 10:
    updateRow[4] = "L"
    updateRow[5] = 301

# DFB LIB-COMP MOD 402
elif (percpsme >= 10 and percpsme < 50) and avedb >= 10:
    updateRow[4] = "M"
    updateRow[5] = 402

# DFB LIB-COMP LOW 401
elif (percpsme >= 10 and percpsme < 50) and avedb < 10:
    updateRow[4] = "L"
    updateRow[5] = 401

# DFB LIB-COMP VLOW 400
elif percpsme < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"
    updateRow[5] = 400
else:
    updateRow[4] = "NOTASSIGN"
    updateRow[5] = 0
else:
    updateRow[4] = "NOSPECperc"
    updateRow[5] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN MOUNTAIN PINE BEETLE IN LODGEPOLE HAZARD")
flist = ["FOREST_ID", "LIFEFORM", "AVEDBH", "CANOPYperc", "MPB_LP_HAZ", "MPB_LP_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            perc_pico = specDict[keyValue][1]
            avedb = updateRow[2]
            canopyperc = updateRow[3]
            # IF STATEMENT FIELDS: perc_pico IS PERCENT_PICO avedb IS AVEDBH canopyperc IS
CANOPYperc
# MPB LP CONS-LIM HIGH 303
if perc_pico >= 50 and avedb >= 8 and (canopyperc >= 34 and canopyperc < 65):

```

```

        updateRow[4] = "H"
        updateRow[5] = 303
    # MPB LP CONS-LIM HIGH      303
    elif percpico >= 50 and (avedbh >= 7 and avedb < 8) and (canopyperc >= 44 and
canopyperc < 65):
        updateRow[4] = "H"
        updateRow[5] = 303

    # MPB LP CONS-LIM MOD
    elif percpico >= 50 and avedb >= 8 and (canopyperc < 34 or canopyperc >= 65):
        updateRow[4] = "M"
        updateRow[5] = 302
    # MPB LP CONS-LIM MOD
    elif percpico >= 50 and (avedbh >= 7 and avedb < 8) and (canopyperc < 44 or
canopyperc >= 65):
        updateRow[4] = "M"
        updateRow[5] = 302
    # MPB LP CONS-LIM MOD
    elif percpico >= 50 and avedb < 7 and (canopyperc >= 34 and canopyperc < 65):
        updateRow[4] = "M"
        updateRow[5] = 302

    # MPB LP CONS-LIM LOW
    elif percpico >= 50 and avedb < 7 and (canopyperc < 34 or canopyperc >= 65):
        updateRow[4] = "L"
        updateRow[5] = 301

    # MPB LP LIB-COMP HIGH
    elif (percpico >= 25 and percpico < 50) and avedb >= 8 and (canopyperc >= 44 and
canopyperc < 65):
        updateRow[4] = "H"
        updateRow[5] = 403

    # MPB LP LIB-COMP MOD
    elif (percpico >= 25 and percpico < 50) and avedb >= 8 and (canopyperc < 44 or
canopyperc >= 65):
        updateRow[4] = "M"
        updateRow[5] = 402
    # MPB LP LIB-COMP MOD
    elif (percpico >= 25 and percpico < 50) and (avedbh >= 7 and avedb < 8):
        updateRow[4] = "M"
        updateRow[5] = 402
    # MPB LP LIB-COMP MOD
    elif (percpico >= 25 and percpico < 50) and avedb < 7 and (canopyperc >= 34 and
canopyperc < 65):
        updateRow[4] = "M"
        updateRow[5] = 402
    # MPB LP LIB-COMP MOD

```

```

        elif (percpico >= 10 and percpico < 25) and avedbh >= 7 and (canopyperc >= 34 and
canopyperc < 65):

```

```

            updateRow[4] = "M"
            updateRow[5] = 402

```

```

        # MPB LP LIB-COMP LOW

```

```

        elif (percpico >= 25 and percpico < 50) and avedbh < 7 and (canopyperc < 34 or
canopyperc >= 65):

```

```

            updateRow[4] = "L"
            updateRow[5] = 401

```

```

        # MPB LP LIB-COMP LOW

```

```

        elif (percpico >= 10 and percpico < 25) and avedbh >= 7 and (canopyperc < 34 or
canopyperc >= 65):

```

```

            updateRow[4] = "L"
            updateRow[5] = 401

```

```

        # MPB LP LIB-COMP LOW

```

```

        elif (percpico >= 10 and percpico < 25) and avedbh < 7:

```

```

            updateRow[4] = "L"
            updateRow[5] = 401

```

```

        # MPB LP LIB-COMP VLOW

```

```

        elif percpico < 10 and updateRow[1] == 4000:

```

```

            updateRow[4] = "VL"
            updateRow[5] = 400

```

```

        else:

```

```

            updateRow[4] = "NOTASSIGN"
            updateRow[5] = 0

```

```

    else:

```

```

        updateRow[4] = "NOSPECPERC"
        updateRow[5] = 0

```

```

    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR

```

```

    updateRows.updateRow(updateRow)

```

```

del updateRows, updateRow

```

```

arcpy.AddMessage("ASSIGN MPB WHITEBARK-LIMBER PINE HAZARD - NO LIMBER PINE ON IP/KNF
FORESTS but in the other tools")

```

```

flist = ["FOREST_ID", "LIFEFORM", "AVEDBH", "CANOPYPERC", "MPB_WBP_HAZ", "MPB_WBP_HAZ_CODE"]

```

```

with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000") as updateRows:

```

```

    for updateRow in updateRows:

```

```

        keyValue = updateRow[0]

```

```

        if keyValue in specDict:

```

```

            percpial = specDict[keyValue][2]

```

```

            avedbh = updateRow[2]

```

```

            canopyperc = updateRow[3]

```

```

            # IF STATEMENT FIELDS: percpial IS PERCENT_PIAL avedbh IS AVEDBH canopyperc IS

```

```

CANOPYPERC

```

```

            # MPB WPB HAZ CONS-LIM HIGH

```

```

if percpcial >= 50 and avedbh >= 7 and canopyperc >= 20:
    updateRow[4] = "H"
    updateRow[5] = 303

# MPB WBP HAZ CONS-LIM MOD
elif percpcial >= 50 and avedbh >= 7 and canopyperc < 20:
    updateRow[4] = "M"
    updateRow[5] = 302
# MPB WBP HAZ CONS-LIM MOD
elif percpcial >= 50 and avedbh < 7 and canopyperc >= 20:
    updateRow[4] = "M"
    updateRow[5] = 302

# MPB WBP HAZ CONS-LIM LOW
elif percpcial >= 50 and avedbh < 7 and canopyperc < 20:
    updateRow[4] = "L"
    updateRow[5] = 301

# MPB WBP HAZ LIB-COMP HIGH
elif (percpcial >= 25 and percpcial < 50) and avedbh >= 12 and canopyperc >= 20:
    updateRow[4] = "H"
    updateRow[5] = 403

# MPB WBP HAZ LIB-COMP MOD
elif (percpcial >= 25 and percpcial < 50) and avedbh >= 12 and canopyperc < 20:
    updateRow[4] = "M"
    updateRow[5] = 402
# MPB WBP HAZ LIB-COMP MOD
elif (percpcial >= 25 and percpcial < 50) and (avedbh >= 7 and avedbh < 12):
    updateRow[4] = "M"
    updateRow[5] = 402
# MPB WBP HAZ LIB-COMP MOD
elif (percpcial >= 25 and percpcial < 50) and avedbh < 7 and canopyperc >= 20:
    updateRow[4] = "M"
    updateRow[5] = 402
# MPB WBP HAZ LIB-COMP MOD
elif (percpcial >= 10 and percpcial < 25) and avedbh >= 7 and canopyperc >= 20:
    updateRow[4] = "M"
    updateRow[5] = 402

# MPB WBP HAZ LIB-COMP LOW
elif (percpcial >= 25 and percpcial < 50) and avedbh < 7 and canopyperc < 20:
    updateRow[4] = "L"
    updateRow[5] = 401
# MPB WBP HAZ LIB-COMP LOW
elif (percpcial >= 10 and percpcial < 25) and avedbh >= 7 and canopyperc < 20:
    updateRow[4] = "L"
    updateRow[5] = 401

```

```

# MPB WBP HAZ LIB-COMP LOW
elif (percpcial >= 10 and percpcial < 25) and avedbh < 7:
    updateRow[4] = "L"
    updateRow[5] = 401

# MPB WBP HAZ LIB-COMP VERYLOW
elif percpcial < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"
    updateRow[5] = 400
else:
    updateRow[4] = "NOTASSIGN"
    updateRow[5] = 0
else:
    updateRow[4] = "NOSPECPERC"
    updateRow[5] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN COMBO MPB HAZARD")
flist =
["FOREST_ID","LIFEFORM","AVEDBH","CANOPYPERC","COMBO_MPB_HAZ","COMBO_MPB_HAZ_CODE"
]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            percpcine = specDict[keyValue][1]+specDict[keyValue][2]+specDict[keyValue][3]
            avedbh = updateRow[2]
            canopyperc = updateRow[3]
            # COMBO MPB CONS-LIM HIGH
            if percpcine >= 50 and avedbh >= 8 and canopyperc >= 34:
                updateRow[4] = "H"
                updateRow[5] = 303
            # COMBO MPB CONS-LIM HIGH
            elif percpcine >= 50 and (avedbh >= 6 and avedbh < 8) and canopyperc >= 44:
                updateRow[4] = "H"
                updateRow[5] = 303

            # COMBO MPB CONS-LIM MOD
            elif percpcine >= 50 and avedbh >= 8 and canopyperc < 34:
                updateRow[4] = "M"
                updateRow[5] = 302
            # COMBO MPB CONS-LIM MOD
            elif percpcine >= 50 and (avedbh >= 6 and avedbh < 8) and canopyperc < 44:
                updateRow[4] = "M"
                updateRow[5] = 302

```



```

# COMBO MPB CONS-LIM MOD
elif percpine >= 50 and avedbh < 6 and canopyperc >= 34:
    updateRow[4] = "M"
    updateRow[5] = 302

# COMBO MPB CONS-LIM LOW
elif percpine >= 50 and avedbh < 6 and canopyperc < 34:
    updateRow[4] = "L"
    updateRow[5] = 301

# COMBO MPB LIB-COMP HIGH
elif (percpine >= 25 and percpine < 50) and avedbh >= 8 and canopyperc >= 44:
    updateRow[4] = "H"
    updateRow[5] = 403

# COMBO MPB LIB-COMP MOD
elif (percpine >= 25 and percpine < 50) and avedbh >= 8 and canopyperc < 44:
    updateRow[4] = "M"
    updateRow[5] = 402
# COMBO MPB LIB-COMP MOD
elif (percpine >= 25 and percpine < 50) and (avedbh >= 6 and avedbh < 8):
    updateRow[4] = "M"
    updateRow[5] = 402
# COMBO MPB LIB-COMP MOD
elif (percpine >= 25 and percpine < 50) and avedbh < 6 and canopyperc >= 34:
    updateRow[4] = "M"
    updateRow[5] = 402
# COMBO MPB LIB-COMP MOD
elif (percpine >= 10 and percpine < 25) and avedbh >= 6 and canopyperc >= 34:
    updateRow[4] = "M"
    updateRow[5] = 402

# COMBO MPB LIB-COMP LOW
elif percpine >= 25 and percpine < 50 and avedbh < 6 and canopyperc < 34:
    updateRow[4] = "L"
    updateRow[5] = 401
# COMBO MPB LIB-COMP LOW
elif percpine >= 10 and percpine < 25 and avedbh >= 6 and canopyperc < 34:
    updateRow[4] = "L"
    updateRow[5] = 401
# COMBO MPB LIB-COMP LOW
elif percpine >= 10 and percpine < 25 and avedbh < 6:
    updateRow[4] = "L"
    updateRow[5] = 401

# COMBO MPB LIB-COMP VERYLOW
elif percpine < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"

```

```

        updateRow[5] = 400
    else:
        updateRow[4] = "NOTASSIGN"
        updateRow[5] = 0
    else:
        updateRow[4] = "NOSPECPERC"
        updateRow[5] = 0
    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
    updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN MPB-WPB PP HAZARD")
flist =
["FOREST_ID","LIFEFORM","AVEDBH","CANOPYPERC","MPB_WPB_PP_HAZ","MPB_WPB_PP_HAZ_CODE
"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            percpiro = specDict[keyValue][3]
            avedbh = updateRow[2]
            canopyperc = updateRow[3]
            # MPB-WPB PP HAZ CONS-LIM HIGH
            if percpiro >= 65 and avedbh >= 10 and canopyperc >= 30:
                updateRow[4] = "H"
                updateRow[5] = 303
            # MPB-WPB PP HAZ CONS-LIM HIGH
            elif percpiro >= 65 and (avedbh >= 6 and avedbh < 10) and canopyperc >= 40:
                updateRow[4] = "H"
                updateRow[5] = 303
            # MPB-WPB PP HAZ CONS-LIM HIGH
            elif (percpiro >= 40 and percpiro < 65) and avedbh >= 10 and canopyperc >= 40:
                updateRow[4] = "H"
                updateRow[5] = 303

            # MPB-WPB PP HAZ CONS-LIM MOD
            elif percpiro >= 65 and avedbh >= 10 and canopyperc < 30:
                updateRow[4] = "M"
                updateRow[5] = 302
            # MPB-WPB PP HAZ CONS-LIM MOD
            elif percpiro >= 65 and (avedbh >= 6 and avedbh < 10) and canopyperc < 40:
                updateRow[4] = "M"
                updateRow[5] = 302
            # MPB-WPB PP HAZ CONS-LIM MOD
            elif percpiro >= 40 and avedbh < 6 and canopyperc >= 30:
                updateRow[4] = "M"
                updateRow[5] = 302

```

```

# MPB-WPB PP HAZ CONS-LIM MOD
elif (percpipo >= 40 and percpipo < 65) and avedbh >= 10 and canopyperc < 40:
    updateRow[4] = "M"
    updateRow[5] = 302
# MPB-WPB PP HAZ CONS-LIM MOD
elif (percpipo >= 40 and percpipo < 65) and (avedbh >= 6 and avedbh < 10):
    updateRow[4] = "M"
    updateRow[5] = 302

# MPB-WPB PP HAZ CONS-LIM LOW
elif percpipo >= 40 and avedbh < 6 and canopyperc < 30:
    updateRow[4] = "L"
    updateRow[5] = 301

# MPB-WPB PP HAZ LIB-COMP MOD
elif (percpipo >= 10 and percpipo < 40) and avedbh >= 6 and canopyperc >= 30:
    updateRow[4] = "M"
    updateRow[5] = 402

# MPB-WPB PP HAZ LIB-COMP LOW
elif (percpipo >= 10 and percpipo < 40) and avedbh >= 6 and canopyperc < 30:
    updateRow[4] = "L"
    updateRow[5] = 401
# MPB-WPB PP HAZ LIB-COMP LOW
elif (percpipo >= 10 and percpipo < 40) and avedbh < 6:
    updateRow[4] = "L"
    updateRow[5] = 401

# MPB-WPB PP HAZ VERY LOW
elif percpipo < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"
    updateRow[5] = 400
else:
    updateRow[4] = "NOTASSIGN"
    updateRow[5] = 0
else:
    updateRow[4] = "NOSPECPERC"
    updateRow[5] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN SB HAZARD")
flist = ["FOREST_ID", "LIFEFORM", "AVEDBH", "CANOPYPERC", "SB_HAZ", "SB_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' = 4000") as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]

```

```

if keyValue in specDict:
    percpien = specDict[keyValue][4]
    avedbh = updateRow[2]
    canopyperc = updateRow[3]
    # SB HAZ CONS-LIM HIGH
    if percpien >= 65 and avedbh >= 16 and canopyperc >= 35:
        updateRow[4] = "H"
        updateRow[5] = 303
    # SB HAZ CONS-LIM HIGH
    elif percpien >= 65 and (avedbh >= 12 and avedbh < 16) and canopyperc >= 45:
        updateRow[4] = "H"
        updateRow[5] = 303
    # SB HAZ CONS-LIM HIGH
    elif (percpien >= 50 and percpien < 65) and avedbh >= 16 and canopyperc >= 45:
        updateRow[4] = "H"
        updateRow[5] = 303

    # SB HAZ CONS-LIM MOD
    elif percpien >= 65 and avedbh >= 16 and canopyperc < 35:
        updateRow[4] = "M"
        updateRow[5] = 302
    # SB HAZ CONS-LIM MOD
    elif percpien >= 65 and (avedbh >= 12 and avedbh < 16) and canopyperc < 45:
        updateRow[4] = "M"
        updateRow[5] = 302
    # SB HAZ CONS-LIM MOD
    elif percpien >= 50 and avedbh < 12 and canopyperc >= 35:
        updateRow[4] = "M"
        updateRow[5] = 302
    # SB HAZ CONS-LIM MOD
    elif (percpien >= 50 and percpien < 65) and avedbh >= 16 and canopyperc < 45:
        updateRow[4] = "M"
        updateRow[5] = 302
    # SB HAZ CONS-LIM MOD
    elif (percpien >= 50 and percpien < 65) and (avedbh >= 12 and avedbh < 16):
        updateRow[4] = "M"
        updateRow[5] = 302

    # SB HAZ CONS-LIM LOW
    elif percpien >= 50 and avedbh < 12 and canopyperc < 35:
        updateRow[4] = "L"
        updateRow[5] = 301

    # SB HAZ LIB-COMP MOD
    elif (percpien >= 10 and percpien < 50) and avedbh >= 12 and canopyperc >= 35:
        updateRow[4] = "M"
        updateRow[5] = 402

```

```

# SB HAZ LIB-COMP LOW
elif (percpie >= 10 and percpie < 50) and avedb >= 12 and canopyperc < 35:
    updateRow[4] = "L"
    updateRow[5] = 401
# SB HAZ LIB-COMP LOW
elif (percpie >= 10 and percpie < 50) and avedb < 12:
    updateRow[4] = "L"
    updateRow[5] = 401

# SB HAZ LIB-COMP VLOW
elif percpie < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"
    updateRow[5] = 400
else:
    updateRow[4] = "NOTASSIGN"
    updateRow[5] = 0
else:
    updateRow[4] = "NOSPECPEC"
    updateRow[5] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN BB PP HAZARD SEVERE")
flist =
["FOREST_ID", "LIFEFORM", "AVEDB", "CANOPYPERC", "BB_PP_SDI_HAZ_S_PRES", "BB_PP_SDI_HAZ_S_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' = 4000") as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            percpie = specDict[keyValue][3]
            avedb = updateRow[2]
            canopyperc = updateRow[3]
            # MPB-WPB PP HAZ CONS-LIM HIGH
            if percpie >= 50 and avedb >= 5 and canopyperc >= 27:
                updateRow[4] = "H"
                updateRow[5] = 503

            # MPB-WPB PP HAZ CONS-LIM MOD
            elif percpie >= 50 and avedb >= 5 and (canopyperc >= 20 and canopyperc < 27):
                updateRow[4] = "M"
                updateRow[5] = 502

            # MPB-WPB PP HAZ CONS-LIM LOW
            elif percpie >= 50 and avedb >= 5 and (canopyperc >= 10 and canopyperc < 20):
                updateRow[4] = "L"

```

```

        updateRow[5] = 501
    elif percipo >= 50 and avedbh < 5:
        updateRow[4] = "L"
        updateRow[5] = 501

    # MPB-WPB PP HAZ LIB-COMP MOD
    elif (percipo >= 25 and percipo < 50) and avedbh >= 5 and canopyperc >= 27:
        updateRow[4] = "M"
        updateRow[5] = 602

    # MPB-WPB PP HAZ LIB-COMP LOW
    elif (percipo >= 25 and percipo < 50) and avedbh >= 5 and (canopyperc >= 10 and
canopyperc < 27):
        updateRow[4] = "L"
        updateRow[5] = 601
    elif (percipo >= 10 and percipo < 25) and avedbh >= 5:
        updateRow[4] = "L"
        updateRow[5] = 601
    elif (percipo >= 10 and percipo < 50) and avedbh < 5:
        updateRow[4] = "L"
        updateRow[5] = 601

    # MPB-WPB PP HAZ VERY LOW
    elif percipo < 10 and updateRow[1] == 4000:
        updateRow[4] = "VL"
        updateRow[5] = 600
    else:
        updateRow[4] = "NOTASSIGN"
        updateRow[5] = 0
else:
    updateRow[4] = "NOSPECPEC"
    updateRow[5] = 0
    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
    updateRows.updateRow(updateRow)
del updateRows, updateRow

```

```

arcpy.AddMessage("ASSIGN BB PP HAZARD LOW-MOD")
flist =
["FOREST_ID", "LIFEFORM", "AVEDBH", "CANOPYPERC", "BB_PP_SDI_HAZ_LM_PRES", "BB_PP_SDI_HAZ_L
M_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' = 4000") as updateRows:
    for updateRow in updateRows:
        keyValue = updateRow[0]
        if keyValue in specDict:
            percipo = specDict[keyValue][3]
            avedbh = updateRow[2]

```

```

canopyperc = updateRow[3]

# MPB-WPB PP HAZ CONS-LIM MOD
if percpiro >= 50 and avedbh >= 5 and canopyperc >= 36:
    updateRow[4] = "M"
    updateRow[5] = 702

# MPB-WPB PP HAZ CONS-LIM LOW
elif percpiro >= 50 and avedbh >= 5 and (canopyperc >= 10 and canopyperc < 36):
    updateRow[4] = "L"
    updateRow[5] = 701
elif percpiro >= 50 and avedbh < 5:
    updateRow[4] = "L"
    updateRow[5] = 701

# MPB-WPB PP HAZ LIB-COMP MOD
elif (percpiro >= 25 and percpiro < 50) and avedbh >= 5 and canopyperc >= 36:
    updateRow[4] = "M"
    updateRow[5] = 802

# MPB-WPB PP HAZ LIB-COMP LOW
elif (percpiro >= 25 and percpiro < 50) and avedbh >= 5 and (canopyperc >= 10 and
canopyperc < 36):
    updateRow[4] = "L"
    updateRow[5] = 801
elif (percpiro >= 10 and percpiro < 25) and avedbh >= 5:
    updateRow[4] = "L"
    updateRow[5] = 801
elif (percpiro >= 10 and percpiro < 50) and avedbh < 5:
    updateRow[4] = "L"
    updateRow[5] = 801

# MPB-WPB PP HAZ VERY LOW
elif percpiro < 10 and updateRow[1] == 4000:
    updateRow[4] = "VL"
    updateRow[5] = 600
else:
    updateRow[4] = "NOTASSIGN"
    updateRow[5] = 0
else:
    updateRow[4] = "NOSPECPERC"
    updateRow[5] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN NONFOREST")

```

```

flist =
["LIFEFORM","DFB_HAZ","DFB_HAZ_CODE","MPB_LP_HAZ","MPB_LP_HAZ_CODE","MPB_WBP_HAZ","
MPB_WBP_HAZ_CODE","COMBO_MPB_HAZ","COMBO_MPB_HAZ_CODE","MPB_WPB_PP_HAZ","MPB_
WPB_PP_HAZ_CODE","SB_HAZ","SB_HAZ_CODE","BB_PP_SDI_HAZ_S_PRES","BB_PP_SDI_HAZ_S_PRES_
CODE","BB_PP_SDI_HAZ_LM_PRES","BB_PP_SDI_HAZ_LM_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' <> 4000') as updateRows:
    for updateRow in updateRows:
        # ASSIGN NONFOREST TO ALL INSECT HAZARD ATTRIBUTES
        updateRow[1] = "NF"
        updateRow[2] = 304
        updateRow[3] = "NF"
        updateRow[4] = 304
        updateRow[5] = "NF"
        updateRow[6] = 304
        updateRow[7] = "NF"
        updateRow[8] = 304
        updateRow[9] = "NF"
        updateRow[10] = 304
        updateRow[11] = "NF"
        updateRow[12] = 304
        updateRow[13] = "NF"
        updateRow[14] = 604
        updateRow[15] = "NF"
        updateRow[16] = 604
        # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
        updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("DONE INSECT HAZ ASSIGNMENTS")

```


APPENDIX H: PYTHON SCRIPT USED FOR HAZARD RATING OF PRE-2015 (OLD) VMAP: Custer, Flathead, Gallatin, Helena, Lewis and Clark, Nez Perce, and a small portion of the Beaverhead Deerlodge National Forests

```
# VMAP FNF/NPC/HLC/CG Forests Assign Insect Hazard Ratings based on category data
# NR FHP Staff, NREGG Jed Gregory and Chip Fisher
# 6-28-2019 Update for attribute name change from Renate Bush
#*****
# This script adds Insect Hazard attributes to VMap polygons
# and fills them in based on VMAP CATEGORICAL Queries eg: DOM40 or DOM6040
# Classes, Tree Canopy Classes and Tree Size Classes.
# Please see THIS REPORT for details on how this script assigns the
# following bark beetle hazard ratings to all polygons:
# Douglas-fir Beetle
# Mountain Pine Beetle in PICO,
# Mountain Pine Beetle in Combined (all) Pines
# Spruce Beetle
# Limited Moderate and Low hazard rating for polygons where host is >=40% are also given for:
# Mountain Pine Beetle, Western Pine Beetle and Ips spp. in PP
# Mountain Pine Beetle in PIAL/PIFL
# Bark Beetle in PIPO Severe Pres
# Bark Beetle in PIPO Low-Mod Pres
#*****
# This script has one argument:
# VMap polygon layer
#####
import arcpy
from arcpy import env

##### SCRIPT ARGUMENTS
VMAP = arcpy.GetParameterAsText(0)

arcpy.AddMessage("CHECK FOR INSECT HAZARD ATTRIBUTES")
if len(arcpy.ListFields(VMAP,"DFB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "DFB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_LP_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "MPB_LP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_WBP_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WBP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"COMBO_MPB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "COMBO_MPB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"MPB_WPB_PP_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WPB_PP_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"SB_HAZ"))!=1:
    arcpy.AddField_management(VMAP, "SB_HAZ", "TEXT", "", "", 10)
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_S_PRES"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_S_PRES", "TEXT", "", "", 10)
```

```

if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_LM_PRES"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_LM_PRES", "TEXT", "", "", 10)

arcpy.AddMessage("CHECK FOR INSECT HAZARD CODE ATTRIBUTES")
if len(arcpy.ListFields(VMAP,"DFB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "DFB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_LP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_LP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_WBP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WBP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"COMBO_MPB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "COMBO_MPB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"MPB_WPB_PP_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "MPB_WPB_PP_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"SB_HAZ_CODE"))!=1:
    arcpy.AddField_management(VMAP, "SB_HAZ_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_S_PRES_CODE"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_S_PRES_CODE", "SHORT")
if len(arcpy.ListFields(VMAP,"BB_PP_SDI_HAZ_LM_PRES_CODE"))!=1:
    arcpy.AddField_management(VMAP, "BB_PP_SDI_HAZ_LM_PRES_CODE", "SHORT")

arcpy.AddMessage("ASSIGN DOUGLAS-FIR BEETLE HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40","DOM_GRP_6040","TREECANOPY","TREESIZE","DFB_HAZ","DFB_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000") as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # DFB CONS-LIM HIGH
        if dom40 == 8025 and treesize in (4400, 4500):
            updateRow[5] = "H"
            updateRow[6] = 103
        # DFB CONS-LIM MOD
        elif dom40 == 8025 and treesize == 4300:
            updateRow[5] = "M"
            updateRow[6] = 102
        # DFB CONS-LIM LOW
        elif dom40 == 8025 and treesize in (4100, 4200):
            updateRow[5] = "L"
            updateRow[6] = 101
        # DFB LIB-COMP MOD
        elif dom40 in (8035, 8400, 8500) and treesize in (4300, 4400, 4500):
            updateRow[5] = "M"
            updateRow[6] = 202
        # DFB LIB-COMP LOW

```

```

elif dom40 in (8035, 8400, 8500) and treesize in (4100, 4200):
    updateRow[5] = "L"
    updateRow[6] = 201
# DFB LIB-COMP VLOW
elif dom40 not in (8025, 8035, 8400, 8500):
    updateRow[5] = "VL"
    updateRow[6] = 200
else:
    updateRow[5] = "NOTASSIGN"
    updateRow[6] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN MOUNTAIN PINE BEETLE IN LODGEPOLE HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40", "DOM_GRP_6040", "TREECANOPY", "TREESIZE", "MPB_LP_HAZ", "MPB_LP_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000") as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # MPB LP CONS-LIM HIGH
        if dom6040 == 8050 and treesize in (4300, 4400, 4500) and treecanopy in (4003, 4004):
            updateRow[5] = "H"
            updateRow[6] = 103
        # MPB LP CONS-LIM HIGH
        elif dom6040 == 8050 and treesize == 4200 and treecanopy == 4004:
            updateRow[5] = "H"
            updateRow[6] = 103
        # MPB LP CONS-LIM HIGH
        elif dom6040 in (8053, 8054) and treesize in (4300, 4400, 4500) and treecanopy == 4004:
            updateRow[5] = "H"
            updateRow[6] = 103
        # MPB LP CONS-LIM MOD
        elif dom6040 == 8050 and treesize in (4300, 4400, 4500) and treecanopy in (4001, 4002):
            updateRow[5] = "M"
            updateRow[6] = 102
        # MPB LP CONS-LIM MOD
        elif dom6040 == 8050 and treesize == 4200 and treecanopy in (4001, 4002, 4003):
            updateRow[5] = "M"
            updateRow[6] = 102
        # MPB LP CONS-LIM MOD
        elif dom6040 in (8053, 8054) and treesize in (4300, 4400, 4500) and treecanopy in (4001, 4002,
4003):
            updateRow[5] = "M"
            updateRow[6] = 102

```

```

# MPB LP CONS-LIM MOD
elif dom6040 in (8053, 8054) and treesize == 4200:
    updateRow[5] = "M"
    updateRow[6] = 102
# MPB LP CONS-LIM LOW
elif dom6040 in (8050, 8053, 8054) and treesize == 4100:
    updateRow[5] = "L"
    updateRow[6] = 101
# MPB LP LIB-COMP MOD
elif dom6040 in (8400, 8500) and treesize in (4200, 4300, 4400, 4500):
    updateRow[5] = "M"
    updateRow[6] = 202
# MPB LP LIB-COMP MOD
elif dom6040 == 8023 and treesize == 4300:
    updateRow[5] = "M"
    updateRow[6] = 202
# MPB LP LIB-COMP LOW
elif dom6040 in (8400, 8500) and treesize == 4100:
    updateRow[5] = "L"
    updateRow[6] = 201
# MPB LP LIB-COMP LOW
elif dom6040 == 8023 and treesize in (4100, 4200, 4400, 4500):
    updateRow[5] = "L"
    updateRow[6] = 201
# MPB LP LIB-COMP VLOW
elif dom6040 not in (8050, 8053, 8054, 8400, 8500, 8023):
    updateRow[5] = "VL"
    updateRow[6] = 200
else:
    updateRow[5] = "NOTASSIGN"
    updateRow[6] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN MOUNTAIN PINE BEETLE IN WHITEBARK PINE/LIMBER PINE HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40", "DOM_GRP_6040", "TREECANOPY", "TREESIZE", "MPB_WBP_HAZ", "MPB_WBP_HAZ_CO
DE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # MPB WBP CONS-LIM HIGH
        if dom6040 in (8120, 8123, 8124, 8150, 8153, 8154) and treesize in (4300, 4400, 4500):
            updateRow[5] = "H"

```

```

        updateRow[6] = 103
    # MPB WBP CONS-LIM MOD
    elif dom6040 in (8120, 8123, 8124, 8150, 8153, 8154) and treesize == 4200:
        updateRow[5] = "M"
        updateRow[6] = 102
    # MPB WBP CONS-LIM LOW
    elif dom6040 in (8120, 8123, 8124, 8150, 8153, 8154) and treesize == 4100:
        updateRow[5] = "L"
        updateRow[6] = 101
    # ASSIGN NOT RATED ALL OTHER CONIFER
    elif dom6040 not in (8120, 8123, 8124, 8150, 8153, 8154):
        updateRow[5] = "NR"
        updateRow[6] = 900
    else:
        updateRow[5] = "NOTASSIGN"
        updateRow[6] = 0
    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
    updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN COMBO MPB HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40","DOM_GRP_6040","TREECANOPY","TREESIZE","COMBO_MPB_HAZ","COMBO_MPB_H
AZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000") as update Rows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # COMBO MPB CONS-LIM HIGH
        if dom40 in (8015, 8055, 8125, 8155) and treesize in (4300, 4400, 4500) and treecanopy in
(4002, 4003, 4004):
            updateRow[5] = "H"
            updateRow[6] = 103
        # COMBO MPB CONS-LIM MOD
        elif dom40 in (8015, 8055, 8125, 8155) and treesize == 4200 and treecanopy in (4002, 4003,
4004):
            updateRow[5] = "M"
            updateRow[6] = 102
        # COMBO MPB CONS-LIM MOD
        elif dom40 in (8015, 8055, 8125, 8155) and treesize == 4100 and treecanopy in (4003, 4004):
            updateRow[5] = "M"
            updateRow[6] = 102
        # COMBO MPB CONS-LIM LOW
        elif dom40 in (8015, 8055, 8125, 8155) and treesize in (4200, 4300, 4400, 4500) and treecanopy
== 4001:
            updateRow[5] = "L"

```

```

        updateRow[6] = 101
    # COMBO MPB CONS-LIM LOW
    elif dom40 in (8015, 8055, 8125, 8155) and treesize == 4100 and treecanopy in (4001, 4002):
        updateRow[5] = "L"
        updateRow[6] = 101
    # COMBO MPB LIB-COMP MOD
    elif dom6040 in (8400, 8500, 8063, 8064, 8074, 8023) and treesize in (4200, 4300) and
treecanopy in (4002, 4003, 4004):
        updateRow[5] = "M"
        updateRow[6] = 202
    # COMBO MPB LIB-COMP LOW
    elif dom6040 in (8400, 8500, 8063, 8064, 8074, 8023) and treesize in (4200, 4300) and
treecanopy == 4001:
        updateRow[5] = "L"
        updateRow[6] = 201
    # COMBO MPB LIB-COMP VERYLOW
    elif dom6040 in (8400, 8500, 8063, 8064, 8074, 8023) and treesize in (4100, 4400, 4500):
        updateRow[5] = "VL"
        updateRow[6] = 200
    # COMBO MPB LIB-COMP VERYLOW
    elif dom6040 in (8020, 8024, 8060, 8070, 8073):
        updateRow[5] = "VL"
        updateRow[6] = 200
    # ASSIGN NOT RATED ALL OTHER CONIFER
    elif dom40 not in (8015, 8025, 8055, 8065, 8075, 8125, 8155, 8400, 8500):
        updateRow[5] = "NR"
        updateRow[6] = 900
    else:
        updateRow[5] = "NOTASSIGN"
        updateRow[6] = 0
    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
    updateRows.updateRow(updateRow)
del updateRows, updateRow

```

```

arcpy.AddMessage("ASSIGN MPB-WPB PP HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40", "DOM_GRP_6040", "TREECANOPY", "TREESIZE", "MPB_WPB_PP_HAZ", "MPB_WPB_PP_
HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' = 4000") as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # MPB-WPB PP HAZ CONS-LIM HIGH
        if dom6040 == 8010 and treesize in (4300, 4400, 4500) and treecanopy in (4002, 4003, 4004):
            updateRow[5] = "H"

```

```

        updateRow[6] = 103
    # MPB-WPB PP HAZ CONS-LIM MOD
    elif dom6040 == 8010 and treesize in (4300, 4400, 4500) and treecanopy == 4001:
        updateRow[5] = "M"
        updateRow[6] = 102
    # MPB-WPB PP HAZ CONS-LIM MOD
    elif dom6040 == 8010 and treesize == 4200 and treecanopy in (4002, 4003, 4004):
        updateRow[5] = "M"
        updateRow[6] = 102
    # MPB-WPB PP HAZ CONS-LIM MOD
    elif dom6040 in (8013, 8014) and treesize in (4300, 4400, 4500) and treecanopy in (4003, 4004):
        updateRow[5] = "M"
        updateRow[6] = 102
    # MPB-WPB PP HAZ CONS-LIM LOW
    elif dom6040 == 8010 and treesize == 4200 and treecanopy == 4001:
        updateRow[5] = "L"
        updateRow[6] = 101
    # MPB-WPB PP HAZ CONS-LIM LOW
    elif dom6040 == 8010 and treesize == 4100:
        updateRow[5] = "L"
        updateRow[6] = 101
    # MPB-WPB PP HAZ CONS-LIM LOW
    elif dom6040 in (8013, 8014) and treesize in (4300, 4400, 4500) and treecanopy in (4001, 4002):
        updateRow[5] = "L"
        updateRow[6] = 101
    # MPB-WPB PP HAZ CONS-LIM LOW
    elif dom6040 in (8013, 8014) and treesize in (4100, 4200):
        updateRow[5] = "L"
        updateRow[6] = 101
    # ASSIGN NOT RATED ALL OTHER CONIFER
    elif dom40 != 8015:
        updateRow[5] = "NR"
        updateRow[6] = 900
    else:
        updateRow[5] = "NOTASSIGN"
        updateRow[6] = 0
    # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
    updateRows.updateRow(updateRow)
del updateRows, updateRow

```

```

arcpy.AddMessage("ASSIGN SB HAZARD")
flist = ["LIFEFORM",
"DOM_MID_40", "DOM_GRP_6040", "TREECANOPY", "TREESIZE", "SB_HAZ", "SB_HAZ_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]

```

```

treecanopy = updateRow[3]
treesize = updateRow[4]
# SB HAZ CONS-LIM HIGH
if dom6040 == 8070 and treesize in (4400, 4500) and treecanopy == 4004:
    updateRow[5] = "H"
    updateRow[6] = 103
# SB HAZ CONS-LIM MOD
elif dom6040 == 8070 and treesize in (4400, 4500) and treecanopy == 4003:
    updateRow[5] = "M"
    updateRow[6] = 102
# SB HAZ CONS-LIM MOD
elif dom6040 == 8070 and treesize == 4300 and treecanopy == 4004:
    updateRow[5] = "M"
    updateRow[6] = 102
# SB HAZ CONS-LIM MOD
elif dom6040 in (8073, 8074) and treesize in (4400, 4500) and treecanopy == 4004:
    updateRow[5] = "M"
    updateRow[6] = 102
# SB HAZ CONS-LIM LOW
elif dom6040 == 8070 and treesize in (4400, 4500) and treecanopy in (4001, 4002):
    updateRow[5] = "L"
    updateRow[6] = 101
# SB HAZ CONS-LIM LOW
elif dom6040 == 8070 and treesize == 4300 and treecanopy in (4001, 4002, 4003):
    updateRow[5] = "L"
    updateRow[6] = 101
# SB HAZ CONS-LIM LOW
elif dom6040 == 8070 and treesize in (4100, 4200):
    updateRow[5] = "L"
    updateRow[6] = 101
# SB HAZ CONS-LIM LOW
elif dom6040 in (8073, 8074) and treesize in (4400, 4500) and treecanopy in (4001, 4002, 4003):
    updateRow[5] = "L"
    updateRow[6] = 101
# SB HAZ CONS-LIM LOW
elif dom6040 in (8073, 8074) and treesize in (4100, 4200, 4300):
    updateRow[5] = "L"
    updateRow[6] = 101
# SB HAZ LIB-COMP MOD
elif dom6040 in (8060, 8064, 8053, 8054, 8500) and treesize in (4300, 4400, 4500) and
treecanopy in (4003, 4004):
    updateRow[5] = "M"
    updateRow[6] = 202
# SB HAZ LIB-COMP MOD
elif dom6040 in (8120, 8123, 8124) and treesize in (4300, 4400, 4500) and treecanopy in (4003,
4004):
    updateRow[5] = "M"
    updateRow[6] = 202

```



```

# SB HAZ LIB-COMP LOW
elif dom6040 in (8060, 8064, 8053, 8054, 8500) and treesize in (4300, 4400, 4500) and
treecanopy in (4001, 4002):
    updateRow[5] = "L"
    updateRow[6] = 201
# SB HAZ LIB-COMP LOW
elif dom6040 in (8060, 8064, 8053, 8054, 8500) and treesize in (4100, 4200):
    updateRow[5] = "L"
    updateRow[6] = 201
# SB HAZ LIB-COMP LOW
elif dom6040 in (8120, 8123, 8124) and treesize in (4300, 4400, 4500) and treecanopy == 4002:
    updateRow[5] = "L"
    updateRow[6] = 201
# SB HAZ LIB-COMP LOW
elif dom6040 in (8120, 8123, 8124) and treesize == 4200:
    updateRow[5] = "L"
    updateRow[6] = 201
# SB HAZ LIB-COMP VLOW
elif dom6040 in (8120, 8123, 8124) and treesize in (4300, 4400, 4500) and treecanopy == 4001:
    updateRow[5] = "VL"
    updateRow[6] = 200
# SB HAZ LIB-COMP VLOW
elif dom6040 in (8120, 8123, 8124) and treesize == 4100:
    updateRow[5] = "VL"
    updateRow[6] = 200
# SB HAZ LIB-COMP VLOW ALL OTHER CONIFER
elif dom6040 not in (8070, 8073, 8074, 8060, 8064, 8053, 8054, 8500, 8120, 8123, 8124):
    updateRow[5] = "VL"
    updateRow[6] = 200
else:
    updateRow[5] = "NOTASSIGN"
    updateRow[6] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

```

```

arcpy.AddMessage("ASSIGN BB PP HAZARD SEVERE")
flist = ["LIFEFORM",
"DOM_MID_40","DOM_GRP_6040","TREECANOPY","TREESIZE","BB_PP_SDI_HAZ_S_PRES","BB_PP_SDI_
HAZ_S_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, ""LIFEFORM" = 4000') as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]
        # BB PP HAZ CONS-LIM HIGH

```

```

        if dom6040 == 8010 and treesize in (4200, 4300, 4400, 4500) and treecanopy in (4002, 4003,
4004):
            updateRow[5] = "H"
            updateRow[6] = 503

        # BB PP HAZ CONS-LIM MOD
        elif dom6040 in (8013, 8014) and treesize in (4200, 4300, 4400, 4500) and treecanopy in (4002,
4003, 4004):
            updateRow[5] = "M"
            updateRow[6] = 502

        # BB PP HAZ CONS-LIM LOW
        elif dom6040 in (8010, 8013, 8014) and treesize in (4200, 4300, 4400, 4500) and treecanopy ==
4001:
            updateRow[5] = "L"
            updateRow[6] = 501
        elif dom6040 in (8010, 8013, 8014) and treesize == 4100:
            updateRow[5] = "L"
            updateRow[6] = 501

        # ASSIGN ALL OTHER CONIFER
        elif dom40 != 8015:
            updateRow[5] = "NR"
            updateRow[6] = 900
        else:
            updateRow[5] = "NOTASSIGN"
            updateRow[6] = 0
        # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
        updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN BB PP HAZARD LOW-MOD")
flist = ["LIFEFORM",
"DOM_MID_40", "DOM_GRP_6040", "TREECANOPY", "TREESIZE", "BB_PP_SDI_HAZ_LM_PRES", "BB_PP_S
DI_HAZ_LM_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' = 4000') as updateRows:
    for updateRow in updateRows:
        dom40 = updateRow[1]
        dom6040 = updateRow[2]
        treecanopy = updateRow[3]
        treesize = updateRow[4]

        # BB PP HAZ CONS-LIM MOD
        if dom6040 in (8010, 8013, 8014) and treesize in (4200, 4300, 4400, 4500) and treecanopy in
(4003, 4004):
            updateRow[5] = "M"
            updateRow[6] = 702

```

```

# BB PP HAZ CONS-LIM LOW
elif dom6040 in (8010, 8013, 8014) and treesize in (4200, 4300, 4400, 4500) and treecanopy in
(4001,4002):
    updateRow[5] = "L"
    updateRow[6] = 701
elif dom6040 in (8010, 8013, 8014) and treesize == 4100:
    updateRow[5] = "L"
    updateRow[6] = 701

# ASSIGN ALL OTHER CONIFER
elif dom40 != 8015:
    updateRow[5] = "NR"
    updateRow[6] = 900
else:
    updateRow[5] = "NOTASSIGN"
    updateRow[6] = 0
# SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
updateRows.updateRow(updateRow)
del updateRows, updateRow

arcpy.AddMessage("ASSIGN NONFOREST")
flist =
["LIFEFORM", "DFB_HAZ", "DFB_HAZ_CODE", "MPB_LP_HAZ", "MPB_LP_HAZ_CODE", "MPB_WBP_HAZ",
MPB_WBP_HAZ_CODE", "COMBO_MPB_HAZ", "COMBO_MPB_HAZ_CODE", "MPB_WPB_PP_HAZ", "MPB_
WPB_PP_HAZ_CODE", "SB_HAZ", "SB_HAZ_CODE", "BB_PP_SDI_HAZ_S_PRES", "BB_PP_SDI_HAZ_S_PRES_
CODE", "BB_PP_SDI_HAZ_LM_PRES", "BB_PP_SDI_HAZ_LM_PRES_CODE"]
with arcpy.da.UpdateCursor(VMAP, flist, "'LIFEFORM' <> 4000') as updateRows:
    for updateRow in updateRows:
        # ASSIGN NONFOREST TO ALL INSECT HAZARD ATTRIBUTES
        updateRow[1] = "NF"
        updateRow[2] = 304
        updateRow[3] = "NF"
        updateRow[4] = 304
        updateRow[5] = "NF"
        updateRow[6] = 304
        updateRow[7] = "NF"
        updateRow[8] = 304
        updateRow[9] = "NF"
        updateRow[10] = 304
        updateRow[11] = "NF"
        updateRow[12] = 304
        updateRow[13] = "NF"
        updateRow[14] = 504
        updateRow[15] = "NF"
        updateRow[16] = 704
        # SAVE THE ROW UPDATE BEING PROCESSED IN THE CURSOR
        updateRows.updateRow(updateRow)

```

```
del updateRows, updateRow
```

```
arcpy.AddMessage("DONE INSECT HAZ ASSIGNMENTS")
```

APPENDIX I: NRGG USER'S GUIDE FOR R1 VMAP INSECT HAZARD RATING GIS TOOLBOX

(copied from NRGG's User's Guide "VMap Insect Hazard Rating Toolbox" publication Ver. June 28, 2019 with limited editing by FHP.)

Description

This Toolbox was created to assign insect hazard ratings to VMap polygons. The insect hazard rating rulesets are for: Douglas-fir Beetle, Mountain Pine Beetle in Lodgepole Pine, Mountain Pine Beetle in Whitebark or Limber Pine, Combined Beetle Hazard in Pines, Mountain Pine Beetle and Western Pine Beetle in Ponderosa Pine, Spruce Beetle, Ponderosa Pine Hazard (and % loss) assuming Severe Beetle Pressure and Ponderosa Pine Hazard (and % loss) assuming Low-Moderate Beetle Pressure. Rulesets have Hazard rating attributes ranging from Very Low to High and a ruleset code attribute. Currently there are three VMap polygon dataset types: pre-2016 data for the Flathead, Nezperce-Clearwater, Helena-LewisClark, and Custer-Gallatin forests, post 2016 data for the Bitterroot, Idaho and Panhandle-Kootenai, and hybrid pre and post 2016 data for the Lolo and Beaverhead Deerlodge forests.

The pre-2016 VMap datasets do not have complete species percent composition for each polygon and a categorical ruleset is used based on: LIFEFORM, DOM_MID_40 or DOM_GRP_6040, TREECANOPY, and TREESIZE attributes.

The post-2016 VMap datasets do have complete species percent composition for each polygon and a continuous ruleset is used for post-2016 data based on: LIFEFORM, Species Percent, CANOPYPERC, and AVEDBH attributes.

The hybrid VMap datasets on the Lolo and BD have mostly post-2016 data with species percent composition but have small areas filled in from the pre-2016 HLC or CG VMap datasets. These two forest VMap datasets will need to run two models.

Source Data

Provide the name of the data, a short description about the data, and the location of the data used for this project.

- *VMap polygons – vegetation polygon datasets created by NRGG*
 - *Forest VMap dataset exported from SDE – Cannot be SDE data because the script cannot add the attributes to SDE data (permissions issue)*
- *Post-2016 VMap Datasets: VMap polygon species percent table for: Bitterroot, Lolo, Idaho Panhandle, Kootenai, and Beaverhead-Deerlodge forests.*
 - *T:\FS\Reference\GIS\r01\Data\VMap\VMap_SpeciesPercent_Tables.gdb*

Process Steps

Process Overview

1. Open Citrix ArcMap at Datacenter
2. Extract VMap Data from SDE to a File Geodatabase
3. Open VMap_InsectHaz Toolbox
4. Run Insect Hazard Tool(s) for Forest VMap Dataset

Running Tools

Start Citrix ArcMap at datacenter

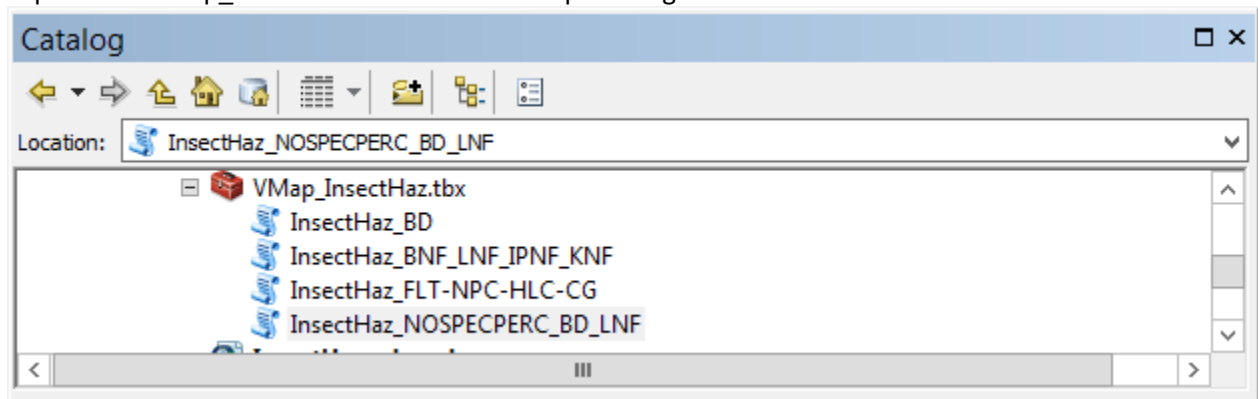
Please contact your forest GIS coordinator for training on using Citrix ArcMap at the datacenter

Open VMap_InsectHaz Scripts Toolbox

In ArcMap open the Catalog tab and navigate to the folder:

T:\FS\Reference\GeoTool\r01\Toolbox

Expand the VMap_InsectHaz Toolbox in ArcMap Catalog Tab



For Flathead, Nezperce-Clearwater, Helena-LewisClark, and Custer-Gallatin VMap Polygons:

Double Click the InsectHaz_FLT_NPC_HLC_CG Tool

Select VMap Polygon layer exported from SDE

For Bitterroot, Idaho Panhandle, and Kootenai VMap Polygons:

Double Click the InsectHaz_BNF_LNF_IPNF_KNF Tool

Select VMap Polygon layer exported from SDE

Select VMap Species Percent Table from:

T:\FS\Reference\GIS\r01\Data\VMap\VMap_SpeciesPercent_Tables.gdb

For Lolo VMap Polygons – Hybrid Dataset:

Double Click the InsectHaz_BNF_LNF_IPNF_KNF Tool

Select VMap Polygon layer exported from SDE

Select VMap Species Percent Table from the location below

T:\FS\Reference\GIS\r01\Data\VMap\VMap_SpeciesPercent_Tables.gdb

After running tool above then

Double Click the InsectHaz_NOSPECERC_BD_LNF Tool

Select VMap Polygon layer used in step above

For Beaverhead-Deerlodge VMap Polygons – Hybrid Dataset:

Double Click the InsectHaz_BD Tool

Select VMap Polygon layer exported from SDE

Select VMap Species Percent Table from the location below

T:\FS\Reference\GIS\r01\Data\VMap\VMap_SpeciesPercent_Tables.gdb

After running tool above then

Double Click the InsectHaz_NOSPECperc_BD_LNF Tool
Select VMap Polygon layer used in step above

Results

Attributes Added to VMap Polygons

Hazard Ratings: VL (very low), L (low), M (moderate), H (High), NR (not rated), NF (nonforest)

DFB_HAZ	Douglas-fir Beetle
MPB_LP_HAZ	Mountain Pine Beetle in Lodgepole Pine
MPB_WBP_HAZ	Mountain Pine Beetle in Whitebark Pine and Limber Pine
COMBO_MPB_HAZ	Combined Mountain Pine Beetle in all pines
MPB_WPB_PP_HAZ	Mountain Pine Beetle & Western Pine Beetle in Ponderosa Pine
SB_HAZ	Spruce Beetle
BB_PP_SDI_HAZ_S_PRES	Bark Beetle in Ponderosa Pine Severe <pressure>
BB_PP_SDI_HAZ_LM_PRES	Bark Beetle in Ponderosa Pine Low-Moderate <pressure>

Hazard Rating Ruleset Codes for pre-2016 VMap: [See Appendices A and E:](#)

103 (Conserv High), 102 (Conserv Mod), 101 (Conserv Low), 204 (Lib High), 203 (Lib Mod), 201 (Lib Low), 200 (Lib Very Low), 104 (nonforest)

Hazard Rating Ruleset Codes for post-2016 VMap: [See Appendices A and D:](#)

303 (Conserv High), 302 (Conserv Mod), 301 (Conserv Low), 404 (Lib High), 403 (Lib Mod), 401 (Lib Low), 400 (Lib Very Low), 304 (nonforest)

DFB_HAZ_CODE	Douglas-fir Beetle code
MPB_LP_HAZ_CODE	Mtn. Pine Beetle in Lodgepole Pine code
MPB_WBP_HAZ_CODE	Mtn. Pine Beetle in Whitebark Pine or Limber Pine code
COMBO_MPB_HAZ_CODE	Combined Mtn. Pine Beetle in all pines code
MPB_WPB_PP_HAZ_CODE	Mtn. or Western Pine Beetle in Ponderosa Pine code
SB_HAZ_CODE	Spruce Beetle code
BB_PP_SDI_HAZ_S_PRES_CODE Bark	Beetle in Ponderosa Pine Severe Code
BB_PP_SDI_HAZ_LM_PRES_CODE Bark	Beetle in Ponderosa Pine Low-Moderate Code